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OKATIBBEE CREEK RESERVOIR, MISSISSIPPI: PREIMPOUNDMENT STUDY

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Federal Water Pollution Control Administration
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PREIMPOUNDMENT STUDY

OKATIBBEE CREEK RESERVOIR, MISSISSIPPI

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UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Southeast Water Laboratory
Technical Programs

JANUARY 1969

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INTRODUCTION

AUTHORITY

By letter dated 25 April 1966, the U. S. Army Engineer District, Mobile, requested the Southeast Region, Federal Water Pollution Control Administration (FWPCA) to ". . . prepare and furnish . . . reports on preimpoundment water quality conditions within the reservoir area and immediately downstream from the Okatibbee Dam . . . near Meridian, Mississippi." Personnel from FWPCA's Southeast Water Laboratory conducted studies needed to answer this request in the winter and summer of 1967. Authority for performing studies of this type may be found in Section 5(a) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.). The full texts of the request for study and the FWPCA reply are contained in Appendix A.

SCOPE

To depict preimpoundment water quality conditions, field studies were designed to show annual variations in significant physical, chemical and biological parameters. Two sampling periods were selected to represent the variations expected, winter and late summer. Data collected were considered representative of a year of normal flows. Extremes of heavy rainfall or drought, however, would effect some changes in the values reported, as will be discussed later.

ACKNOWLEDGMENTS

In the conduct of field investigations, numerous agencies and individuals cooperated with FWPCA personnel. For their assistance, we extend special thanks to:

(a) City of Meridian officials for providing laboratory space and for assisting in selection of certain sampling points.

(b) U. S. Geological Survey, Jackson, Mississippi, for providing streamflow data.

(c) U. S. Army Engineer District, Mobile, for furnishing streamflow data and for permitting access to sampling points near the damsite.

BACKGROUND

In April 1966, the U. S. Army Engineer District in Mobile, Alabama, requested the Federal Water Pollution Control Administration to determine preimpoundment water quality conditions for the Okatibbee Creek Reservoir near Meridian, Mississippi. Field studies were conducted by personnel from FWPCA's Southeast Water Laboratory in 1966 and 1967.

The studies were designed to determine annual variations in significant physical, chemical, and biological water quality parameters within and immediately downstream from the reservoir watershed. From the field data collected, together with information reported from earlier studies (1963) by the Public Health Service (1), a good description of preimpoundment water quality was obtained.

Okatibbee Creek Reservoir was designed to provide flood protection, water supply, recreation, and water quality control. With regard to the latter use, the reservoir will be the first Federal project completed in the southeastern United States for which storage has been provided to assist in maintenance of desired downstream water quality. A good quality water within the reservoir and in reservoir releases is needed for all projected uses. A dissolved oxygen concentration in reservoir releases of not less than 4.0 mg/l was recommended for water quality control in the 1963 studies.

SUMMARY OF FINDINGS

(1) Okatibbee Creek Reservoir has a 154 square mile watershed which, at present, has seen little man-made development. Land use is 75 percent woodland, 10 percent pastureland, 10 percent cropland, and the remainder residential. The terrain consists mostly of silty sands and clays.

(2) The average operating pool depth of the reservoir will be approximately nine feet with a corresponding surface area of 3,800 acres.

(3) Stream discharge at the dam site averages approximately 180 cfs. Almost zero streamflow occurs during drought periods.

(4) Physical and chemical preimpoundment water quality was determined from USPHS studies in 1963, a reconnaissance survey in October 1966, and from intensive surveys in winter and summer 1967. These surveys showed that:

(a) The waters of Okatibbee Creek and its tributaries in the reservoir drainage area have a low mineral content. Total solids concentrations were usually less than 100 mg/l, three-fourths of which was the dissolved fraction. Hardness and alkalinity concentrations were consistently less than 25 mg/l as $CaCO_3$.

(b) The pH of these streams rarely ranges more than 0.5 units from neutrality.

(c) Water temperature will reach 29°C maximums and could possibly climb to the low 30's during hot dry spells.

(d) Turbidity values exceed 25 Jackson candle units during storm runoff periods, but generally reflect the low sediment loads prevalent within the watershed.

(e) The waters are stained the typical brown color found in streams within the southern U. S. coastal plain. Color values were as high as 130, but generally ranged from 50 to 100 units.

(f) Dissolved oxygen saturation values on the main stem of Okatibbee Creek were consistently greater than 70 percent, except during extreme low flow when 50 percent values have been reported (USPHS 1963 studies). The coupling of low flow, hot weather conditions, and the presence of oxygen-demanding substances affects smaller tributaries more adversely than the main stem. Average dissolved oxygen concentrations were less than 4 mg/l (down to 2.9 mg/l) on three small tributaries in August-September 1967.

(g) The 5-day BOD (BOD_5) values were usually less than 2 mg/l. A 3.4 mg/l BOD_5 maximum was observed in the 1966 and 1967 surveys, but values as high as 6.1 mg/l were observed during the low-flow, USPHS studies in 1963.

(h) The inorganic nitrogen content was as high as 0.54 mg/l as N, during winter 1967. Organic nitrogen frequently exceeded 0.50 mg/l. Total phosphorus concentrations reached as high as 0.06 mg/l as P.

(i) Total iron and manganese are present in sufficient quantity to caution against potential water quality problems following impoundment. The dissolved fractions were not measured but should be included in any postimpoundment studies.

(j) The existing water supply for the city of Meridian, which consists of both water from wells and from a series of impoundments, is, in some respects, of better physical and chemical water quality than Okatibbee Creek or its tributaries. Observed turbidity values were

less than 25 Jackson Candle units, color never exceeded 20 units, and conductivity in the principal water source (impoundments) was less than 40 μmhos. High iron and manganese concentrations reported in the past were not observed during the 1967 studies.

(5) Bacteriological studies showed that:

(a) Very low total and fecal coliform densities existed in March 1967 at all sampling points, with the highest average densities being 400/100 ml and 245/100 ml respectively. These low densities appeared to be a reflection of the stable flow conditions existing at that time.

(b) Considerably higher indicator densities existed during the September study. Total coliform count averages ranged from 6,100 to 19,000/100 ml and fecal coliform from 50 to 780/100 ml. Again, the weather and flow conditions, which were reversed from the March study, appeared to be reflected by the counts obtained.

(c) Livestock and wildlife appear to be the major indicator contributors within the study area.

No significant domestic waste sources exist within the area. A considerable amount of livestock grazing area will be eliminated by impoundment.

(d) The Meridian water supply impoundment had a lower bacterial content than Okatibbee Creek or its tributaries. Total and fecal coliform counts never exceeded 40/100 ml and 3/100 ml respectively.

(6) The studies of aquatic biota revealed that:

(a) Okatibbee Creek and its major tributaries upstream from Meridian are biologically healthy, i.e. they support a diverse biota typical of a non-polluted enviornment.

(b) Waste introduction between Stations 9 and 10 effects a change in benthic forms from sensitive to pollution-tolerant.

(c) No excessive algal growths exist in streams in the reservoir watershed.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that:

1. Initial impoundment of Okatibbee Creek will decrease bacterial counts from levels observed during preimpoundment studies to levels acceptable for primary contact recreation. Continued satisfactory bacterial levels for primary contact recreation will be contingent on the implementation of an adequate waste management program to coincide with any watershed development.
2. In spite of the shallowness of the reservoir, impoundment may be expected to introduce thermal stratification and its attendant problems of low dissolved oxygen and buildup of dissolved iron and manganese in the hypolimnion. Downstream water quality could be affected adversely by hypolimnetic discharges.
3. From a water supply standpoint, the quality of water within Okatibbee Creek Reservoir should approximate that of Meridian's existing water supply impoundments. Compared to preimpoundment water quality in the Okatibbee Creek watershed, quality improvements (as related to water supply uses) will result from impoundment through a decrease in suspended solids and bacterial densities, and a smoothing of annual water quality variations.

4. The current potential for occurrence of nuisance biological problems associated with reservoir eutrophication is low, but development of the watershed and reservoir periphery could increase the possibility of accelerated eutrophication.

It is recommended:

1. That a program for waste management in the Okatibbee Reservoir drainage basin be established by responsible agencies prior to any increase in commercial, industrial, residential, or other waste-generating development. The water supply, recreation and water quality control features of the reservoir project must be protected. Regulations pertaining to sanitation within the reservoir proper would be a part of the program and should include prohibiting the discharge of wastes from watercraft.
2. That studies be performed as soon as possible following impoundment to determine if stratification produces water quality problems downstream from the dam, and, if found to occur, that remedial measures be taken promptly to protect the water quality control aspects of the project. A minimum DO in reservoir releases of 4.0 mg/l has been recommended previously.
3. That any water supply intakes built within the reservoir be designed to withdraw water selectively from different water levels - this to enable the use of best quality waters in the likely event of stratification.

DESCRIPTION OF PROJECT AND PROJECT AREA

OKATIBBEE DAM AND RESERVOIR

The Corps of Engineers is currently constructing a 6,500 foot long, 50 foot high dam approximately seven miles northwest of Meridian, Mississippi, in Lauderdale County. This dam, to be known as Okatibbee Dam, will store runoff from a 154 square mile drainage area. The 109,800 acre-feet (at spillway crest elevation) of storage capacity behind the dam will be used primarily for flood protection but will also be used for water supply, fish and wildlife conservation, general recreation, and water quality control. Some 34,400 acre-feet of storage has been allocated for water supply and water quality control. At seasonal pool elevation (343 feet above mean sea level), the reservoir will cover 3,800 acres. Approximately 8,800 acres will be inundated at flood storage elevation 359. Releases from the reservoir will be controlled through an intake located at the bottom of the dam. Figure 1 shows the general location of the reservoir.

Water supply benefits will extend primarily to Meridian and Lauderdale County. The existing water supply sources in the area have been judged to have insufficient yield for future demand, and in addition, there are iron and manganese water quality problems.

Water quality benefits, described in an earlier report (1), also will apply principally to the Meridian area. At the present time, treated municipal waste and untreated industrial waste from Meridian enter Sowashee Creek, the principal tributary of Okatibbee Creek (Figure 2; rear of report). These waste discharges cause severe pollution in Sowashee Creek for most of its length and in Okatibbee Creek from Sowashee Creek to its junction with

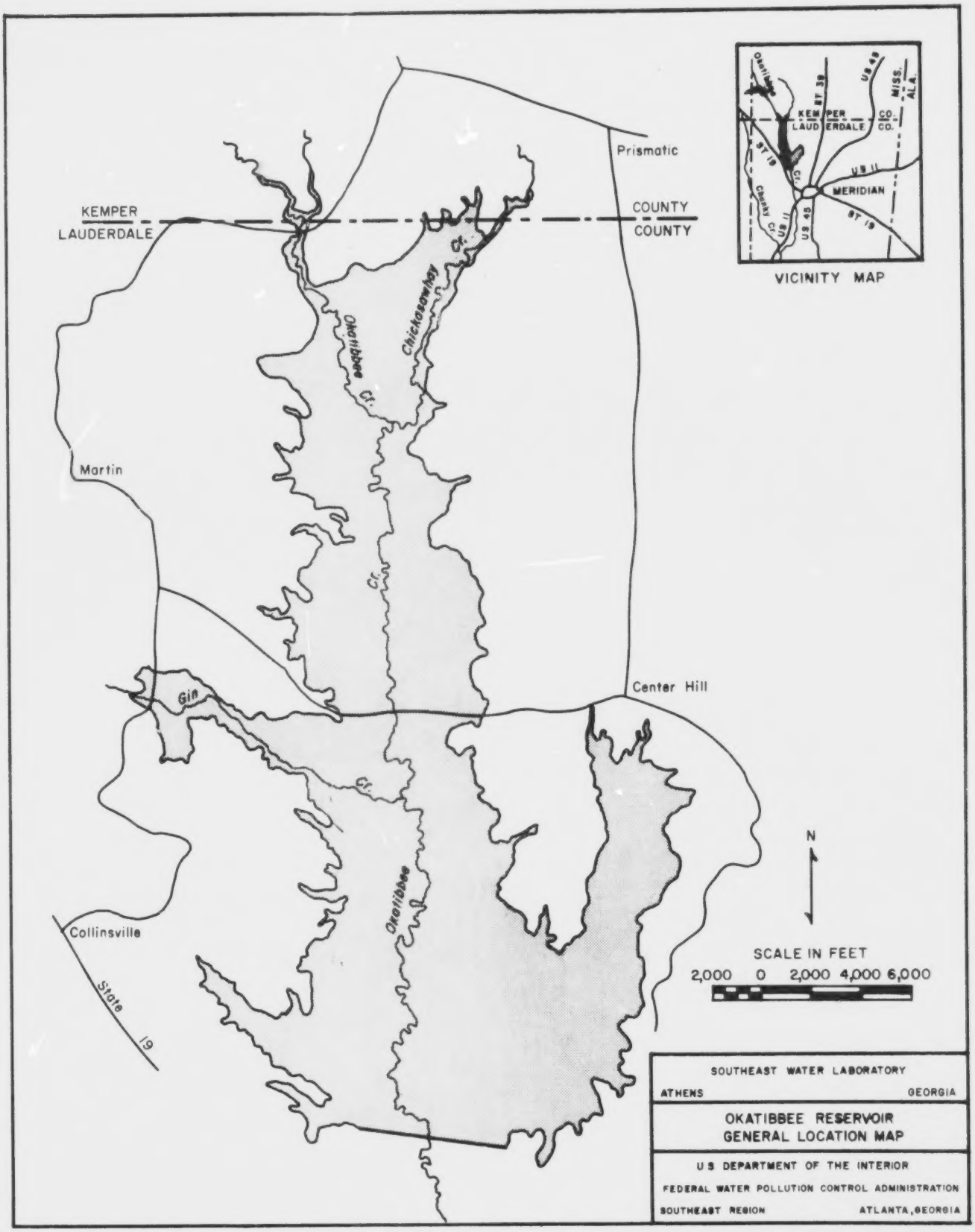

Prismatic
KEMPER
LAUDERDALE
COUNTY
COUNTY
Okatibbee Cr.
Chickasawhay Cr.
Martin
Cr.
Gin
Center Hill
Cr.
Okatibbee
Collinsville
State 19
N
SCALE IN FEET
2,000 0 2,000 4,000 6,000
Okatibbee
US 45
MISS.
ALA.
ST 39
KEMPER
LAUDERDALE
CO.
CO.
ST 19
Cr.
US 11
MERIDIAN
Chenay Cr.
US 45
ST 19
VICINITY MAP
SOUTHEAST WATER LABORATORY
ATHENS
GEORGIA
OKATIBBEE RESERVOIR
GENERAL LOCATION MAP
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION
ATLANTA, GEORGIA

FIGURE 1

Chunky Creek, some 14 miles downstream. With provision of adequate treatment for all municipal and industrial wastes and with supplemental flow from the new reservoir, the quality of Okatibbee Creek and a section of the Chickasawhay River will again be restored for beneficial use (1).

A good quality water is needed in Okatibbee Reservoir for recreation, water supply, and water quality control. The studies reported here depict existing water quality in Okatibbee Creek below the dam site, in sections of the creek and other streams to be impounded, and in the tributaries which will feed the reservoir. Water quality which will exist in the reservoir can be predicted to a certain extent from these preimpoundment studies.

OKATIBBEE CREEK WATERSHED - PHYSICAL AND HYDROLOGIC CHARACTERISTICS

Okatibbee Creek rises near the southern part of the Neshoba-Kemper county line in east central Mississippi. From here it flows southeasterly through a section of the North Central Plateau subdivision of the Gulf Coastal Plain. The stream is fed by a number of springs in Kemper County, especially on the Houston Creek tributary. Upstream from the dam, Okatibbee Creek meanders sharply within a limited floodplain while it passes through Lauderdale County. A few swamp-like zones may be found adjacent to the stream in this area. In the Kemper County headwaters region, the terrain is more hilly and the streambed slope more pronounced (about 24 feet per mile).

Throughout the 154 square mile Okatibbee Creek watershed, the banks of the main stream and its several tributaries are covered with heavy foliage. Light penetration is held to a minimum by shielding vegetation. At many sampling points, decaying vegetation (primarily trees) had fallen into the streams.

Land use within the reservoir drainage basin is restricted to woodland (75 percent *), pastureland (10 percent *), and cropland (10 percent *). The remainder is for residential use. There are no municipalities - resident population being restricted to a scattering of farm homes distributed along the county roads which traverse the basin. Sanitary control of the watershed, a desirable feature for a water supply reservoir, would be difficult in spite of the small resident population. Pastureland drainage is difficult to control.

The terrain through which Okatibbee Creek passes consists, for the most part, of silty clays, sandy clays, and silty sands. During storm runoff, the sediment load carried by streams in the basin can be high. Severe erosion problems, however, have been minimized by the large percentage of woodland cover. During reservoir construction and initial filling, erosion will become a short-term problem, and efforts should be made to minimize soil loss. The reservoir is being cleared completely below the seasonal pool elevation.

Long-term flow records for Okatibbee Creek are available for only one gaging station, a USCS recording gage on old U. S. Highway 80 near Meridian. The drainage area at this point is 239 square miles, 55 percent greater than the area at the dam. For 29 years of record, the average discharge at the gage has been 288 cfs (2). This amounts to a 1.2 cfs/sq. mi. yield, and, if direct ratio is assumed, the average flow at the dam for the same period would be approximately 184 cfs. Flow extremes at the damsite range from nearly no flow at times to over 20,000 cfs during floods. Since there will be no

* - Approximately

power development at the dam, it can be expected that sustained flow releases, if of good quality, will be an asset for the area, minimizing the water quality damaging aspects of both extremely high and low streamflow.

The principal tributaries (Figure 2) to Okatibbee Creek in the reservoir watershed area are Bales Creek, Gin Creek, Houston Creek (shown as Little Creek on some maps), and Chickasawhay Creek (shown as Pender Creek on some maps).

STUDY METHODS

FIELD SAMPLING PROGRAM

During presurvey reconnaissance in the fall of 1966, thirty-one sites tentatively were selected for water quality and/or biological sampling. Five of these were eliminated before sampling began, and, of the twenty-six remaining, eleven were located on the main stem of Okatibbee Creek. Some samples were taken from the wells and lakes which supply raw water to the Meridian water treatment plant. The sampling frequency at each stream station was established according to the size of stream. Figure 2 shows the location of all sampling stations. A description of sampling sites is located in Appendix B.

Three sampling periods were established:

(a) Reconnaissance - October 27, 1966: to determine general physical, chemical, and bacteriological parameter levels.

(b) Winter - March 14-17, 1967: to determine water quality conditions during a cold weather, high runoff period.

(c) Summer - August 29 - September 6, 1967: to determine water quality conditions during a sustained hot weather, low runoff period.

The desired sampling conditions for the winter and summer surveys were not met entirely. Figure 3 shows that streamflow in March 1967 was below the annual average flow of 288 cfs at the USGS Hwy. 80 gage. In August and September, while flows were usually less than 50 cfs [1/] at Hwy 80, the sampling period was preceded by a storm of short duration which elevated streamflow to a peak of 200 cfs. Additional rain fell during the survey (Table I).

[1/] The 7-day, 10-year low at the Hwy 80 gage has been reported as 1.7 cfs (3).

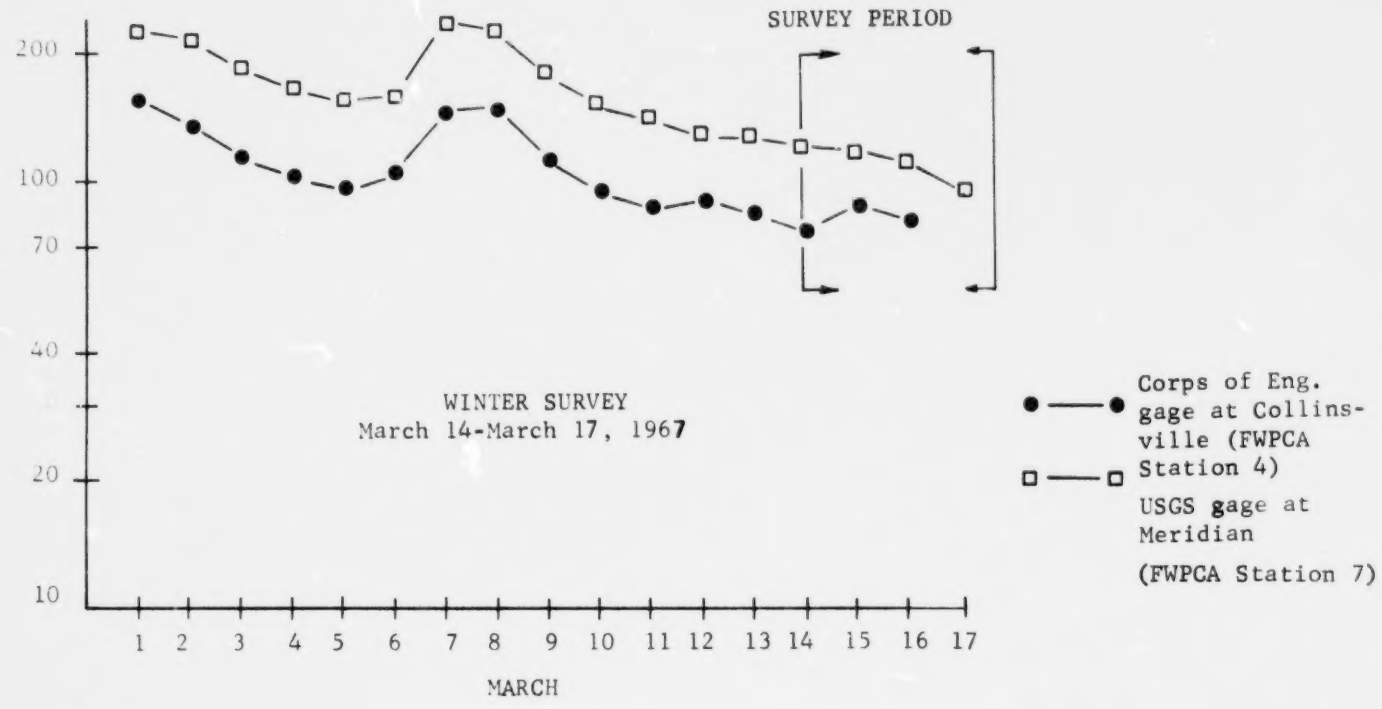
TABLE I

RAINFALL DATA *
AUGUST 21 - SEPTEMBER 9, 1967

Date	Rainfall(in.)	Ave. Temperature (°F)
August 21	T	79°
August 22	0	79°
August 23	T	79°
August 24	1.56	79°
August 25	0.75	76°
August 26	0.10	76°
August 27	0	75°
August 28	0	75°
August 29	0	74°
August 30	0	73°
August 31	0	73°
September 1	0	68°
September 2	0	66°
September 3	0	65°
September 4	T	69°
September 5	0.01	71°
September 6	0.23	67°
September 7	0.83	70°
September 8	0	75°
September 9	T	75°

*From the Environmental Science Center, Meridian, Miss.

T = trace



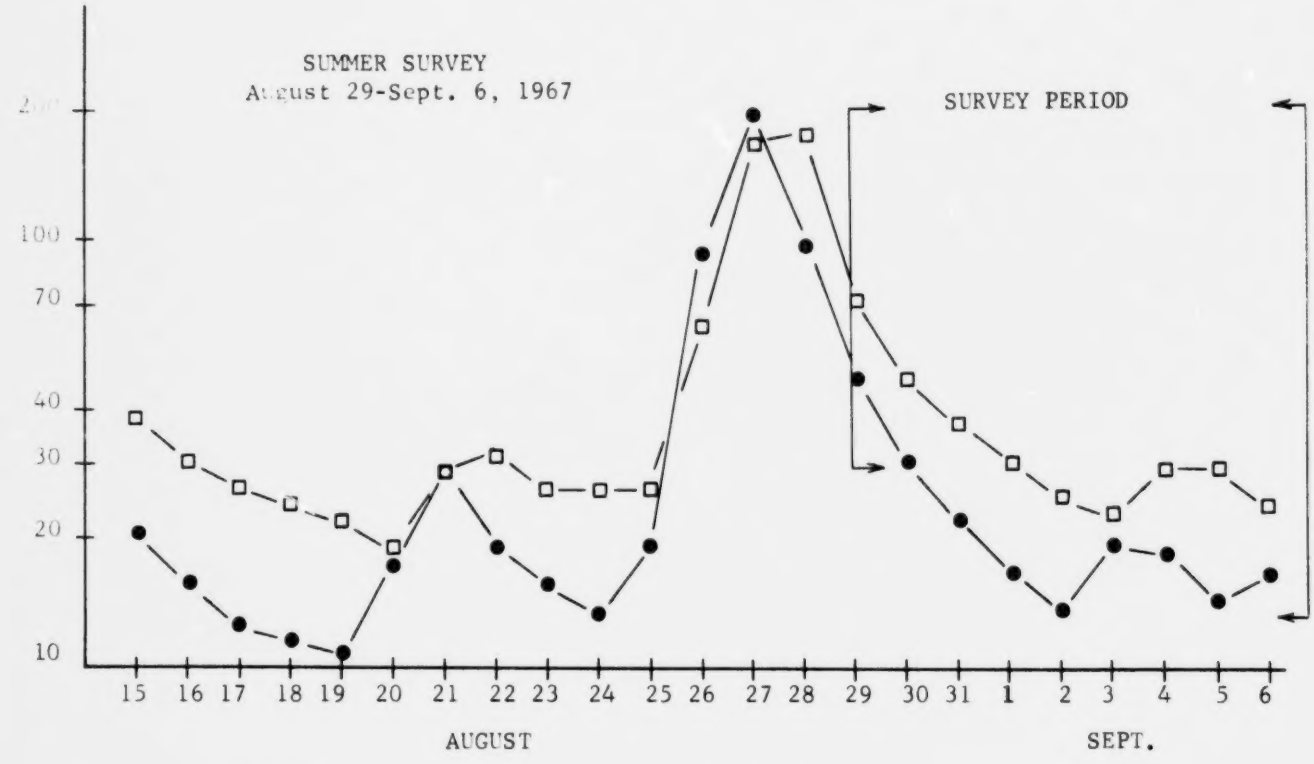


FIGURE 3. STREAMFLOW DURING SURVEY PERIODS.

In spite of these minor deviations from desired flow conditions, the sample analysis results were felt to be representative of normal annual water quality variations within the Okatibbee Reservoir drainage basin and in the creek downstream from the dam. Streamflow at the U. S. Hwy 80 gage was stable at about 25 cfs during the 1966 reconnaissance survey. The effect of low flow on water quality is represented best by the 1963 Public Health Service study findings (1) which are also discussed in this report.

Grab sampling techniques (one sample per day) were adopted for the preimpoundment survey. Time of sampling at each station was varied in order to account for diurnal water quality fluctuations. Samples were collected daily on larger streams and on a different schedule on the smaller tributaries.

Construction activities created disturbance of streambeds and occassionally affected water quality at a number of sampling stations (1F, 3, 3A, 3C, 3E, and 5). Because of this, no biological sampling sites were selected in disturbed streambed areas. The effect of construction activities on water quality pertained only to August-September 1967 studies and was not deemed significant. Usually only turbidity and suspended solids parameters were affected (increased values) and then only during heavy runoff.

STUDY FINDINGS

PREVIOUS STUDY INFORMATION

During field investigations conducted for the 1963 Public Health Service water resource study of Okatibbee Creek Reservoir (1), some water quality data were obtained for main stem sampling stations 1 through 10. These data, reproduced in Appendix C, reflect grab and composite sample analyses made in November and December 1963. Samples were taken following an extended dry period, and flows during the survey seldom exceeded 20 cfs at the U. S. Hwy 80 streamflow gage. Temperatures ranged widely between 2 and 18°C. In comparison to the cold weather preimpoundment survey of March 1967, the 1963 study reflected a slightly lower temperature regime and an order of magnitude lower streamflow.

For a detailed examination of the 1963 data, reference is made again to Appendix C. Concentrations or values of such water quality parameters as total and dissolved solids, pH, alkalinity, hardness, and chlorides were much the same in 1963 as in March 1967. Dissolved oxygen (DO) and 5-day biochemical oxygen demand (BOD_5) values, on the other hand, differed significantly between the two study periods. The DO levels in 1963 on days when flow was lowest declined to 5.2 mg/l at Station 3, 4.9 mg/l at Station 4, and zero at Station 10 below Meridian's waste input. The BOD_5 values which were as high as 5.3 mg/l at Station 4 and 6.1 mg/l at Station 6 reflected again the low flow existing during this survey period. Dissolved oxygen and BOD_5 levels for 1967 are discussed in detail in a later section, but a comparison between the two studies definitely indicates that low flow conditions (1963) will detrimentally affect water quality in the main stem of Okatibbee Creek. This is particularly evident in the stream reach

immediately downstream from the dam (Stations 4, 5, and 6). Quiescent pools containing settled organic debris, which exist during low flow periods, will be particularly prone to lowered water quality. It would still be considered unusual, however, for DO concentrations in Okatibbee Creek above Station 9 to fall below 4.0 mg/l for extended periods and over reaches more than a few hundred feet long.

SOURCES OF WASTE

At present there are no sources of municipal or industrial waste within the Okatibbee Creek Reservoir watershed. Those wastes which enter the watershed as a result of man's activities are limited primarily to runoff from cropland and livestock grazing areas. Domestic wastes from a few rural homes may reach tributaries of Okatibbee Creek. A concentrated livestock production area (reportedly for development of serums) is located in the Gin Creek drainage area.

PHYSICAL AND CHEMICAL WATER QUALITY

Types and Methods of Analysis

Table II shows the type and method of analysis for the various physical and chemical parameters measured. Samples were collected for physical and chemical analysis during every sampling period previously described.

TABLE II. PHYSICAL AND CHEMICAL ANALYSES AND METHODS

Type Analysis	Measurement Method	Where Measured
Temperature	Glass or bimetallic thermometer	Sampling site
pH	Battery and line-operated meters	Field lab
Turbidity	Jackson candle Turbidimeter	" "
Color	Standard Methods*	" "
Conductivity	Line-operated meter	" "
Dissolved oxygen (DO)	Standard Methods (azide modifications)*	" "
Biochemical oxygen demand (BOD)	" "	" "
Chlorides	Standard Methods* (mercuric nitrate)	" "
Sulfates	" "	" "
Total hardness	" "	" "
Calcium	" "	" "
Iron	Atomic absorption spectrophotometer	Southeast Water Lab
Manganese	" " "	" " "
Organic Nitrogen	Technicon AutoAnalyzer technique	" " "
Nitrate-Nitrite	" " "	" " "
Ammonia	" " "	" " "
Total phosphate	" " "	" " "
Orthophosphate	" " "	" " "
Total solids	Standard Methods*	Field lab
Suspended solids	" "	" "
Volatile solids	" "	" "
Dissolved solids	By difference	

*Standard Methods for the Examination of Water and Wastewater, Twelfth Edition, 1965.

1966 Reconnaissance Survey

Grab samples were collected from Stations 1A, 1F, 2, 3, and 4 on October 27, 1966. The purpose of this one-day survey was to obtain information on general levels of various water quality parameters prior to initiation of more intensive sampling. Water temperature was approximately 13°C, and main stem streamflow was stable at 24 cfs (Hwy 80 gage) on this date. Results of sample analyses are shown in Table III.

In spite of relatively low flow, oxygen saturation values were 80 percent and higher at all stations except 1F.[1/] Analyses showed a pH neutral body of waters with low mineral content, little evidence of organic pollution, typical brown stain, and average bacterial density. Total dissolved solids fell within a narrow range of from 56 to 63 mg/l; BOD_5 was less than 1.5 mg/l at all stations; color was between 80 and 110 units; and total coliform counts varied from 1,200 to 4,500/100 ml.

A high COD/BOD_5 ratio (17:1 at Station 4) suggested that organics present in the watershed streams were stable, i.e. they resisted biodegradation. The presence of tannin and lignin-like compounds could account for the relatively high COD values (20.2 mg/l at Station 4).

Results of the reconnaissance survey generally portended that further surveys would show water of good quality with little water quality variation between sampling points.

1/ This station was located in a pool of a very small stream where flow was less than 1 cfs.

TABLE III

OCTOBER 27, 1966, RECONNAISSANCE SURVEY DATA

STA.#	DISSOLVED OXYGEN (mg/l)	BOD (mg/l) 5-DAY	BOD (mg/l) 7-DAY	COD (mg/l)	ALKALINITY (mg/l as $CaCO_3$)	CONDUCTIVITY (μmhos)	TURBIDITY (Jackson Candle Units)	COLOR (UNITS)	SOLIDS TOTAL (mg/l)	SOLIDS SUSPENDED (mg/l)	SOLIDS DISSOLVED (mg/l)	MANGANESE (mg/l)
1-A	8.3	0.9	1.1	17.3	16.0	51	< 5	90	71	8	63	0.10
1-F	4.0	0.4	1.9	15.3	16.0	50	10	90	102	41	61	0.16
2	8.7	1.0	1.4	14.4	13.0	36	5	80	62	6	56	0.08
3	9.6	1.4	2.8	16.0	13.0	44	10	110	65	9	56	0.14
4	9.0	1.2	1.2	20.2	13.0	46	< 5	90	69	9	60	0.18

STA.#	HARDNESS (mg/l as $CaCO_3$) TOTAL	Ca	Mg	SULFATE (mg/l)	CHLORIDE (mg/l)	TEMPERATURE (°C) Air	H_2O	pH	TOTAL COLIFORM (MF Technique) (No./100 ml)
1-A	16.0	9.0	7.0	17.1	6	20	13.0	6.9	2,800
1-F	17.4	8.2	9.2	14.0	6	20	13.5	6.8	1,200
2	14.4	7.2	7.2	14.2	7	20.5	13.5	7.0	1,200
3	15.2	8.8	6.4	19.0	6	20.5	13.0	6.8	1,300
4	13.0	7.6	5.4	2.5	7	17.5	13.5	7.0	4,500

NOTE: Streamflow at USGS Hwy 80 gage was 24 cfs at time of sampling and had been stable for several days prior to sampling.

1967 Surveys

For comparative purposes the March and August-September survey data are discussed together. Because of poor roads and road conditions, not every station was sampled in March.

During each survey, samples were obtained from the raw water intake at the Meridian water plant. The source of water for Meridian is both wells and surface water impoundments. Ground water is used to supplement the surface water supply. Severe manganese problems in the impoundments, with concentrations as high as 5.0 mg/1, have been reported in the past (4).

Average, maximum, and minimum values for the various water quality parameters measured are summarized in Appendix D.

Physical Quality - During both cold and warm weather phases of the study, pH values ranged within 0.5 units of neutrality. In March the average of pH values for all samples was 6.9, while in August-September it increased only slightly to 7.2. With pH in the neutral range during the warm weather survey, there is some indication that algal production (which is usually associated with elevated pH values) in the watershed streams was minimal.

Temperatures ranged from 11° to 20°C in March and from 19° to 29°C in the late summer survey. It is known that temperatures can approach lows of zero degrees Centigrade in the winter, while during extremely hot and dry periods which are common in the Meridian area, maximum temperatures in the low 30's (°C) would not be unusual. As expected, the main stem stations had the least temperature variation during the summer survey, 19-21°C at Station 1, 20-23°C at Station 3 and 19 to 23°C at Station 4. Widest ranges were on small tributaries such as Station 3B (19°-29°), 1F (19°-26°), and 3A (19°-24°).

Turbidity is a water quality parameter which can reflect either sediment loads carried by streams or excessive algal growth or both. Turbidity was not measured during the cold weather survey but general observations indicated that waters sampled were not turbid although they were stained. These observations also were borne out during the August-September survey. Even though Okatibbee Creek and its tributaries were passing out of a peak flow period during the first four days of the warm weather study, the turbidity values (in Jackson candle units) rarely exceeded 25 at any station. When rain began again on September 4, with few exceptions the turbidity was still consistently less than 25 units. Construction activities at Stations 3 (left bank only) and 3A and below the dam at Station 5 contributed to the higher turbidities reported at these sites. Maximums of 400 units at Station 3, 32 at Station 3A and 140 at Station 5 were observed. The turbidity values for the entire survey, even with variable streamflow conditions, reflected bodies of waters with low sediment load and little algal activity. The streams in the reservoir watershed appeared to have a high capacity for turbidity reduction following runoff. Turbidity at the Meridian water supply impoundment intake was less than 25 on two samples in September.

Past reference has been made to the color in Okatibbee Creek and its tributaries. The colors observed were the typical brown stains found in coastal plain streams of the southern United States. Color values were generally the same in the reservoir watershed and below. During the cold weather survey, averages ranged from 67 units on the platinum cobalt scale at Station 3A to 95 units at Station 3B. Individual values ranged from 45

to 110 with main stem stations usually in the 60 to 80 range. In the August-September survey, the observed color values were generally the same as in March, although addition of Stations 2A and 2B produced lows of 35 and 25 respectively. The maximum value for the summer survey was 130 units at Station 3A. Samples from Meridian's water supply sources showed colors ranging from zero for well water up to 20 for the surface water impoundments.

Conductivity, Solids, Hardness, and Alkalinity - Conductivity measurements, as an indicator of the dissolved mineral content, were low during both cold and warm weather surveys. March averages ranged from 55 to 73 micromhos (μmhos), while individual results in September were slightly lower, 29 to 67 μmhos. At main stem Stations 1, 2, 3, and 3A, the September conductivity values varied narrowly between 41 and 44 μmhos. Compared to Meridian's well water supply, the conductivity of Okatibbee Creek waters was low, 240 μmhos versus less than 100 μmhos. Samples from the water supply impoundment intake, however, indicated a slightly lower dissolved mineral content than in the reservoir watershed (26 and 40 μmhos for two samples).

The low mineral content indicated by conductivity measurements was substantiated by solids analyses. While stable streamflow conditions existed in March, the total solids content ranged in a narrow band from 63 to 103 mg/l (84 mg/l average for all samples). A reduced number of total solids analyses in September showed a variation of from 50 to 175 mg/l (97 mg/l average). The slightly higher September values probably reflected either peaking flow conditions or the greater contribution to total streamflow from groundwater sources - normal during drier periods. Dissolved solids constituted approximately three-fourths of the total solids during both surveys.

At the Meridian water treatment plant, total solids was 102 mg/l on a well sample; the dissolved fraction was 90 percent. An impoundment sample had only 48 mg/l total solids in March.

Hardness analyses performed during the 1966 reconnaissance survey revealed very soft waters in the Okatibbee Creek Reservoir watershed. The surveys of 1967 did nothing to belie these findings. The hardness concentrations for both cold and warm weather surveys averaged 25 mg/l or less at all but two small tributary streams.

Alkalinity levels in most southern U. S. surface waters are usually low, 50 mg/l and less. Again, the waters within the reservoir watershed proved to be no exception. Alkalinity concentrations consistently averaged less than 20 mg/l at most stations, and only one value greater than 30 mg/l was observed in any stream (31 mg/l at Station 3F). Contrasted with watershed water quality, alkalinity concentrations in Meridian's existing water supply sources were both higher and lower. Analyses showed 8 mg/l or less in the water supply impoundment and 79 mg/l in the ground water supply.

DO and BOD_5 - The absence of significant point source waste discharges above Okatibbee Creek Dam would tend to preclude problems of low DO or high BOD_5 in the watershed. Natural BOD in swamp drainage, however, has been associated with low DO values in parts of the South. Some effect of such drainage was observed in the DO analyses for this study.

During the survey of March 1967, only three DO analyses showed saturation values less than 75 percent. At Station 3H, a stream draining a swamp-like area, the saturation values were as low as 67 percent. [1/] The individual dissolved oxygen concentrations in March shown in Figure 5 ranged from 6.2 mg/l (Station 3H) to 11.7 mg/l (Station 3B) and averaged over

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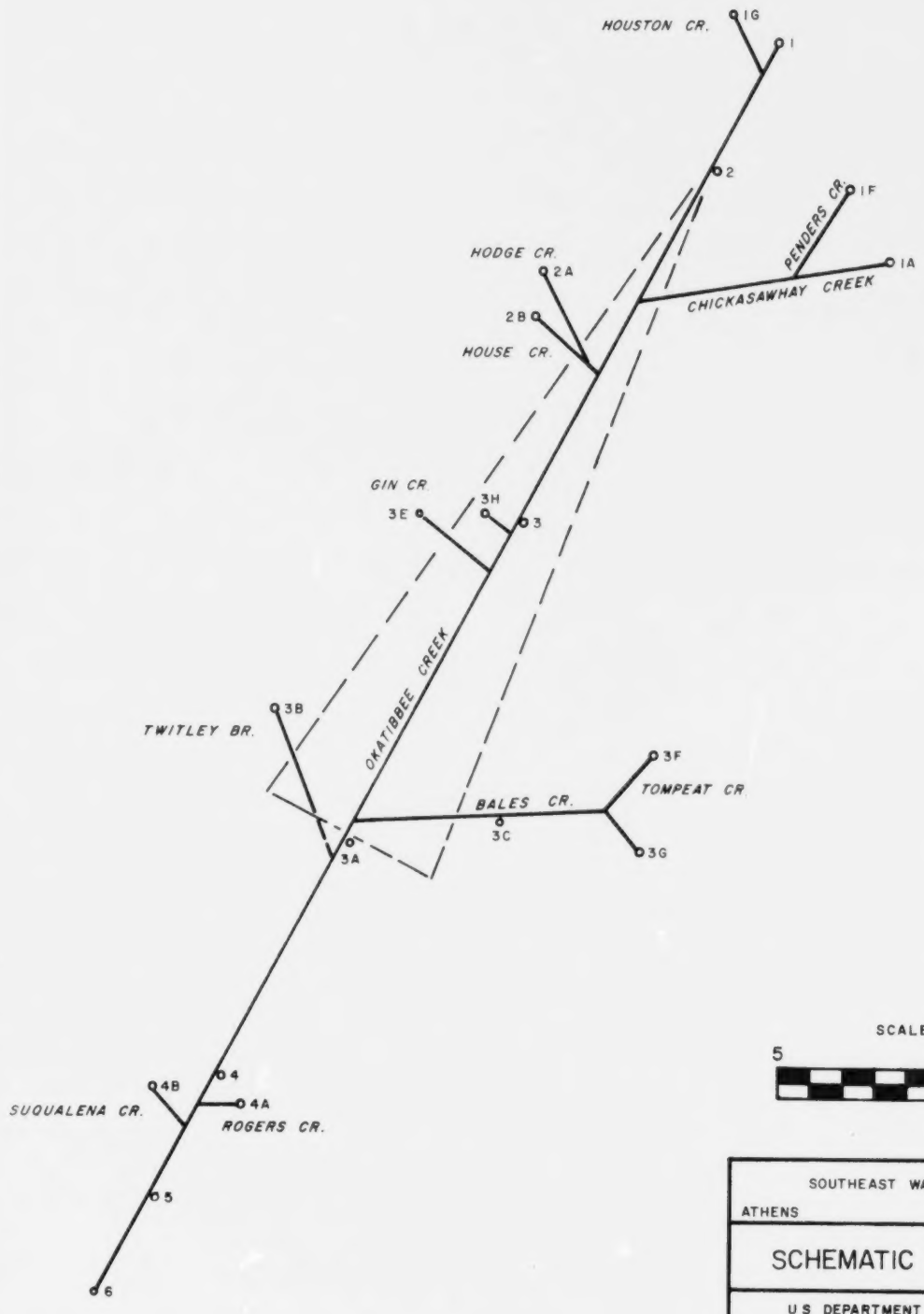
1/ A value of 85 percent is generally considered normal for streams with overall good water quality.



SCALE IN MILES

5 0 5

SOUTHEAST WATER LABORATORY

ATHENS GEORGIA

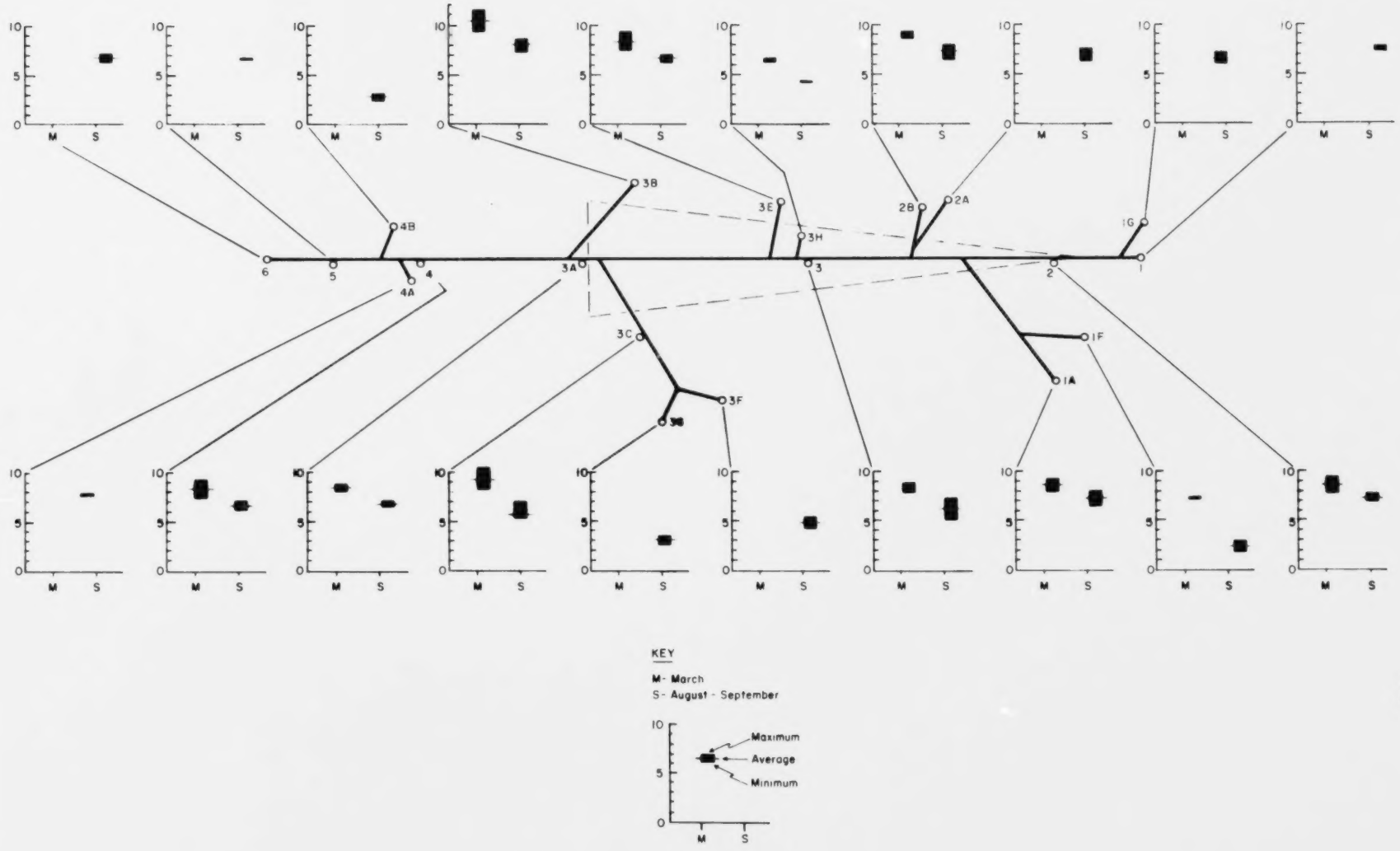
SCHEMATIC LOCATION MAP

U S DEPARTMENT OF THE INTERIOR

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 4



KEY

M - March

S - August - September

FIGURE 5. DISSOLVED OXYGEN CONCENTRATIONS (mg/l)

ACE

8 mg/l at most stations. Some evidence of algal activity was noted at Station 3B, the small Twittley Branch tributary, where oxygen saturation values for two samples were 103 and 113 percent. On only one occasion in March did main stem samples have saturation values less than 80 percent.

With the reduced streamflow and higher temperatures characteristic of late summer, the DO concentrations dropped to a range of from 1.9 to 8.8 mg/l (Figure 5). With the exception of some of the smaller tributaries, the DO saturation values remained at levels of 70 percent and higher, higher especially at main stem sampling sites. Significant DO depression on smaller tributaries in August-September was observed at Stations 1F, 3C, 3F, 3G, 3H, and 4B (only 1F, 3C, and 3H were sampled during the March survey). Where streamflow was measured at these stations, no measurement exceeded 1 cfs. Only at Station 3C were stream velocities observed to exceed 1 fps; as low as 0.1 fps (Station 3F) was recorded. Coupled with the presence of livestock in some areas (3F and 3G) or in some cases swamp-like drainage (1F and 3H), it was not unusual to find depressed DO concentrations. The depression at Station 3C to a minimum of 5.1 mg/l was not as severe as at the others above and probably reflected livestock grazing conditions at upstream Stations 3F and 3G. Station 4B was located downstream from the dam on Suqualena Creek, and it is not known if there were waste discharges in this area. Average dissolved oxygen concentrations were less than 4 mg/l at three stations; 1F, 3G, and 4B.

The BOD_5 values for the March and August-September surveys were usually less than 2 mg/l. The highest BOD_5 was 3.4 mg/l at Station 3E in March. Five-day oxygen demands such as these reflect unpolluted waters and also

suggest that the depressed DO values noted above were not associated with short-term oxygen demands from suspended or dissolved organics. More likely, benthic deposits and/or nitrogenous demands were the cause of DO reductions.

Nitrogen and Phosphorus - Figure 6 depicts results of organic and inorganic nitrogen analyses for the two 1967 surveys. Where more than one analysis per station was completed, which was usually the case, average concentrations are shown. Inorganic nitrogen (nitrate, nitrite, and ammonia) [1/] levels found during late winter and early spring are frequently considered to be the amount of this nutrient available for plant growth during warm weather periods. The range of average inorganic nitrogen concentrations in March was from 0.34 to 0.54 mg/l as N. These concentrations are in the range frequently found in southern U. S. surface waters where no problems of excessive algal growth have been observed. The inorganic nitrogen values of the August-September survey reflected utilization of this nutrient for plant growth. Average concentrations in the reservoir watershed dropped to a range of from 0.06 to 0.22 mg/l, the lower value at Station 3H and the higher at Station 3G.

Organic nitrogen concentrations also decreased between March and August (Figure 6). Concentrations frequently exceeded 0.50 mg/l in March but were usually less than 0.40 mg/l in the late summer survey.

Phosphorus and nitrogen are considered the two most important plant nutrients in water. Figure 7 shows average total phosphorus concentrations (as P) for the two 1967 surveys. A decrease in phosphorus content following

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[1/] Inorganic nitrogen values in March considered only nitrate and ammonia forms.

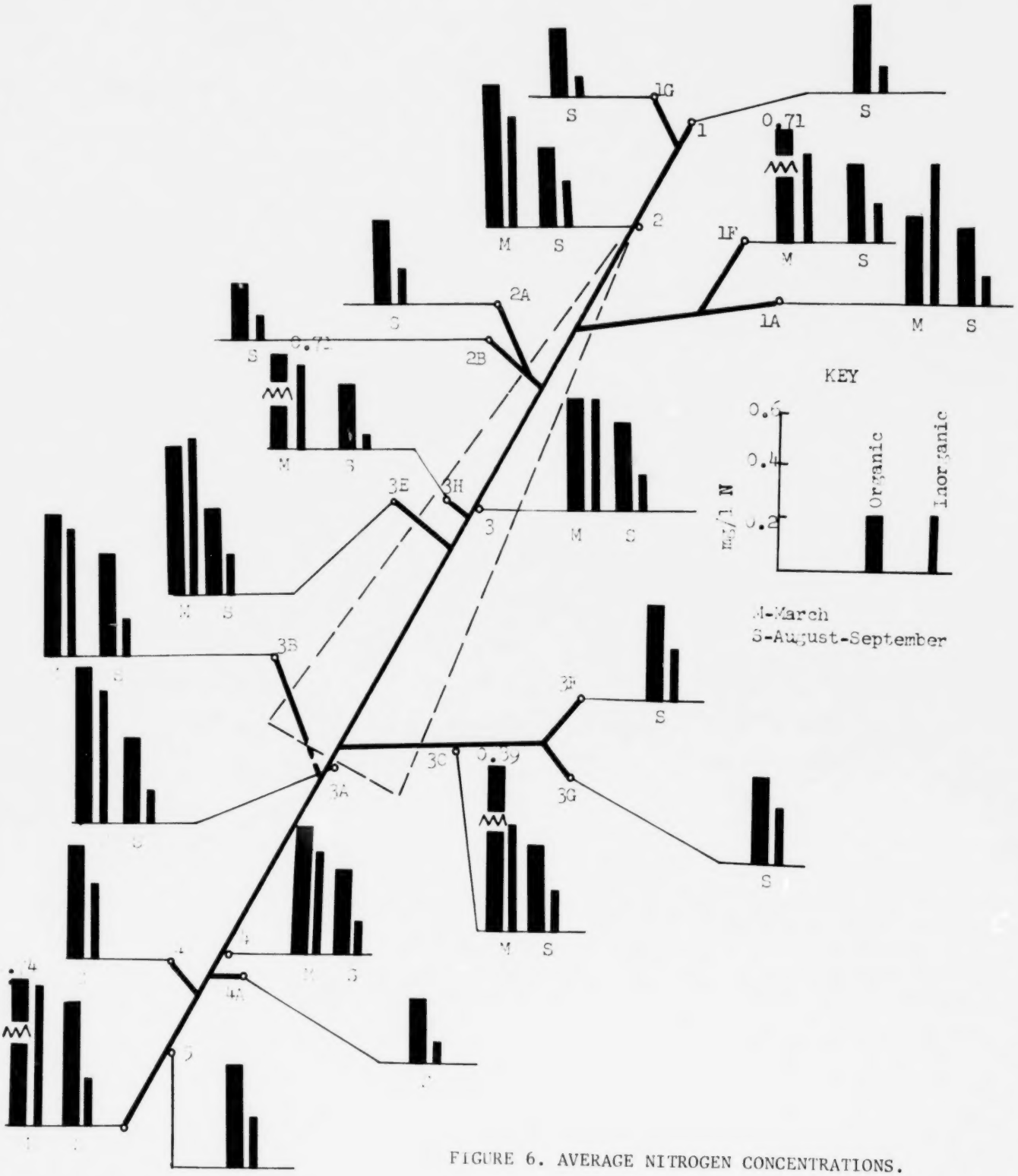

FIGURE 6. AVERAGE NITROGEN CONCENTRATIONS.

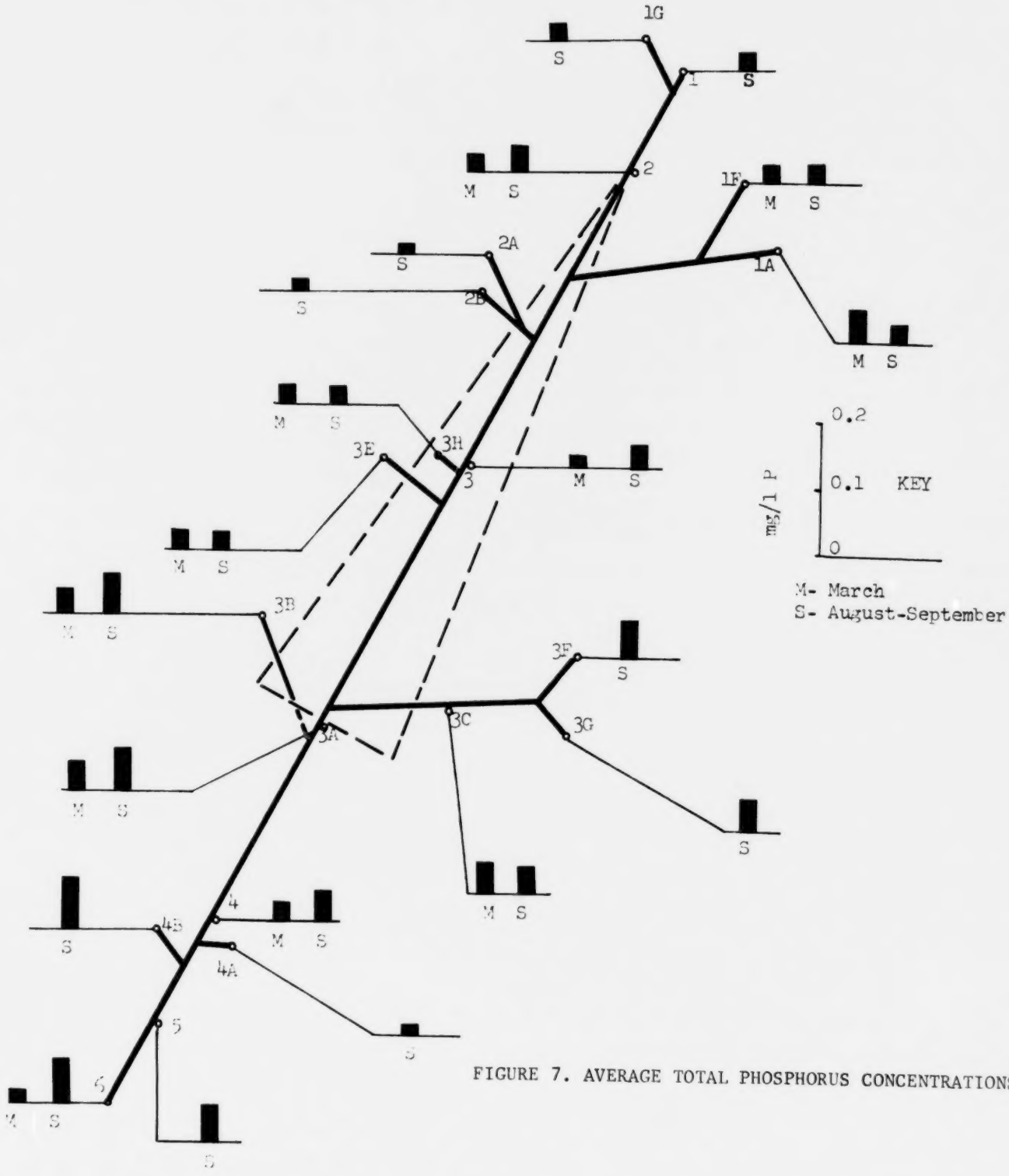

FIGURE 7. AVERAGE TOTAL PHOSPHORUS CONCENTRATIONS.

the active plant growth period was not evident. During March, individual analytical results varied from 0.02 to 0.06 mg/l (over 50 percent was of the more available orthophosphate form). In August - September, results ranged from 0.01 to 0.10 mg/l. An overall average total P for stations in the reservoir watershed was 0.04 mg/l during both surveys.

Mackenthun (5) has suggested allowable total phosphorus levels for prevention of biological nuisances as 0.1 mg/l P in flowing streams and 0.05 mg/l P where waters enter a lake. The latter value was equalled or exceeded many times in samples taken from Okatibbee Creek Reservoir tributaries. This, however, does not necessarily indicate that nuisance aquatic growth will occur once the reservoir is filled. Phosphorus concentrations much higher than 0.1 mg/l have been reported throughout the Southeast with no evidence of attendant nuisance growth problems. What the Mackenthun numbers do indicate is a possibility which should not be overlooked.

Iron and Manganese - Total iron and manganese concentrations are shown in Figures 8 and 9. No attempt was made in this study to separate dissolved and particulate fractions. The former are considered more important from a damage to water supply standpoint, and it is suggested that post-impoundment studies include analyses for both forms of these metals.

An overall average for total iron concentrations was calculated for both surveys. The March average was 2.60 mg/l, and August-September was 3.96 mg/l. Higher values in the summer were probably related to runoff. Individual values as high as 4.24 mg/l (Station 3B) in March and 8.25 mg/l (same station) in September were observed. The most prevalent form of iron was assumed to be particulate because of the oxygen and pH levels in the streams.

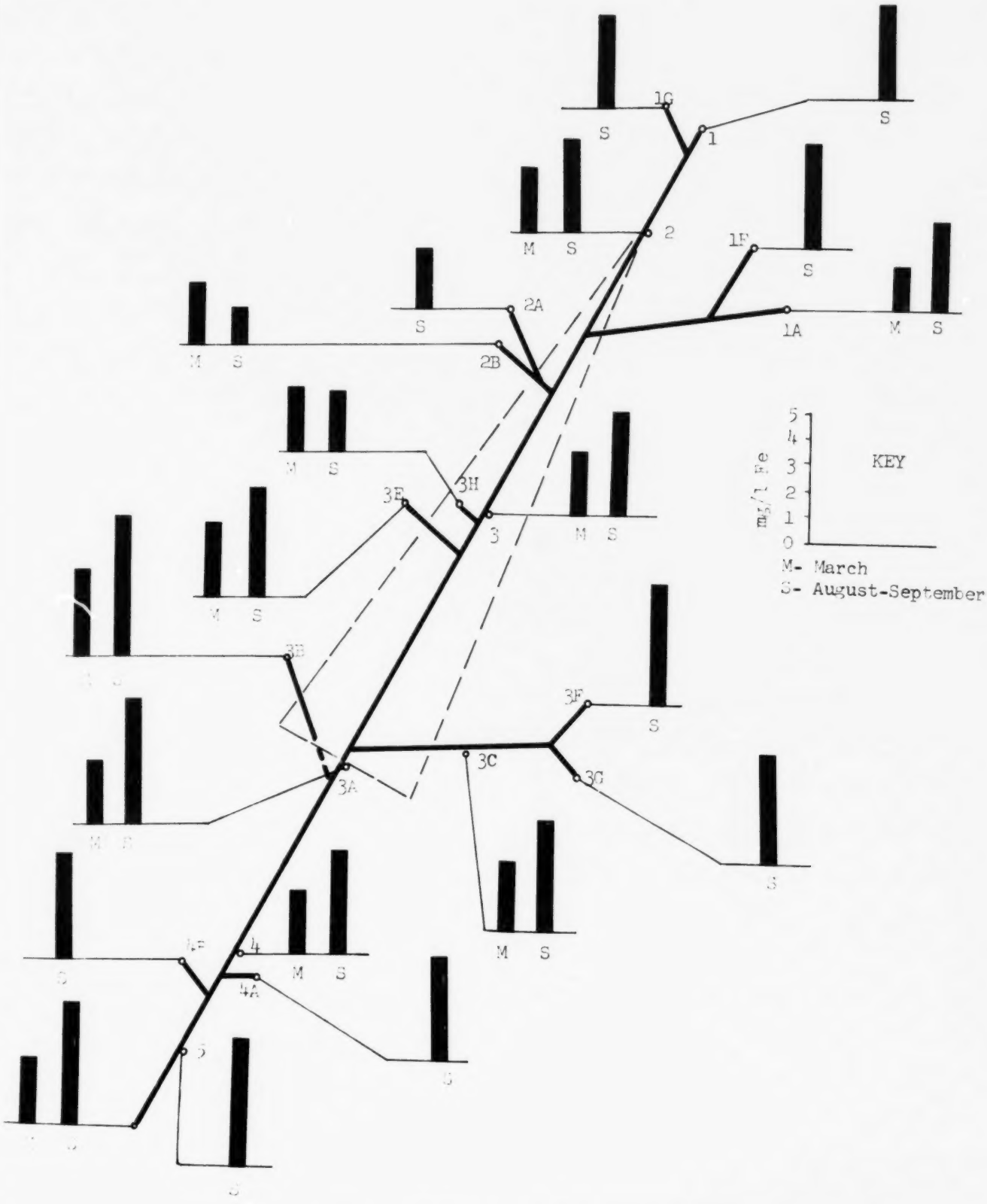

FIGURE 8. AVERAGE TOTAL IRON CONCENTRATIONS.

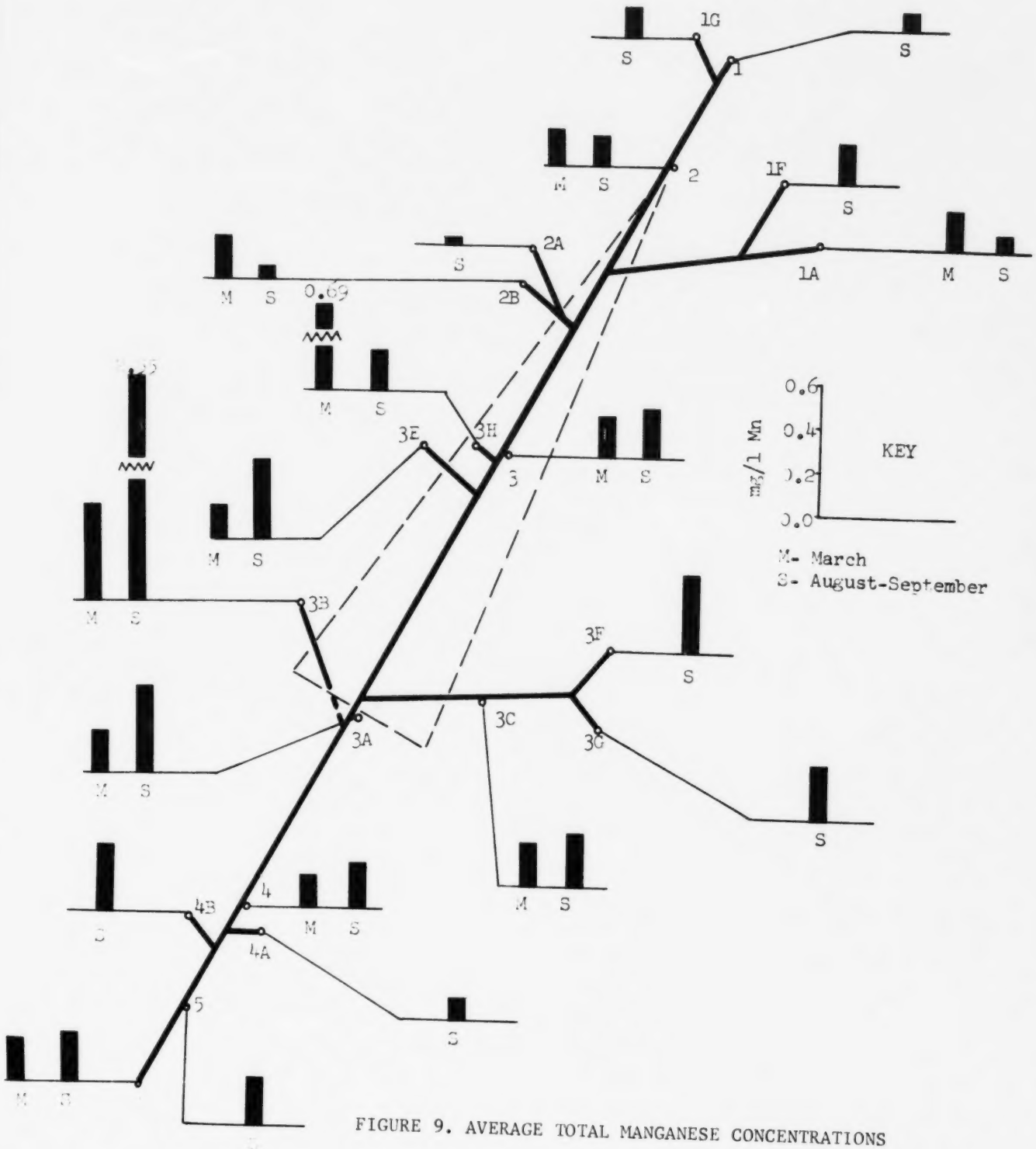

FIGURE 9. AVERAGE TOTAL MANGANESE CONCENTRATIONS

As with iron, the cold weather average for total manganese (0.23 mg/1) was lower than the warm weather (0.32 mg/1) and probably for the same reason. It cannot be assumed, however, that particulate forms were predominant.

The levels of both iron and manganese in the reservoir watershed tend to indicate a potential water quality problem once impoundment occurs. Further discussion on this point follows in another section.

BACTERIOLOGICAL WATER QUALITY

Sampling and Enumeration Methods

The March 1967 survey consisted of a three-day study in which twelve stations (1A, 1F, 2, 2B, 3, 3A, 3B, 3C, 3E, 3H, 4, and the Meridian Water Plant) were sampled. The August-September survey consisted of a five-day study in which all stations were sampled.

All samples collected were of surface water and were collected using the grab technique. In March, each of the samples was analyzed for total and fecal[1/] coliforms and in August-September for total and fecal coliforms and fecal streptococci. Also, during each of the surveys "one-shot" attempts were made at several of the stations to isolate Salmonella.

Total coliforms and fecal streptococcal densities were determined using the membrane filter techniques as outlined in Standard Methods (6). The fecal coliform density was determined using the method of Geldreich et al (7). Salmonella detection was attempted using the modified swab technique of Spino (8).

Results

In general, the area was free from any major waste sources other than those associated with agricultural operations. Hence, the major fecal bacteria

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1/ Meaning derived from the intestinal tracts of warm-blooded animals.

contribution was from the livestock and wildlife within the study area. All bacteriological data for the 1967 surveys are contained in tables in Appendix D.

As the summarized data in Table IV indicate, the total coliform densities in streams during the March sampling period were low for flowing streams, ranging from an average count of 95/100 ml at Station 2 to an average of 400/100 ml at Station 3C. Such low values were attributed in part to the dry weather, stable flow conditions during the study period. At the water plant, samples from the water supply reservoir showed a total coliform density even lower than in the streams, 10/100 ml average density.

Total coliform densities during the August-September study were considerably higher than those of the March study at comparable stations (Table V). Counts ranged from an average of 6600/100 ml at Station 1G to an average of 19,000/100 ml at Station 2A. The extreme differences between the March and August-September total coliform values at all stations appeared to be the result of rainfall that occurred during the week preceding the latter study. The influence on total coliform densities of peaking streamflows at several main stem stations is shown in Figure 10. Higher total coliform values in the August-September survey do not necessarily reflect serious bacterial pollution in the Okatibbee Creek Reservoir watershed since total coliforms of non-fecal origin are introduced with storm runoff. Any increase in flows resulting from surface runoff should produce corresponding increases in indicator densities, perhaps at even higher densities than shown in this report.

At the Meridian raw water intake, the total coliform count was higher than in March but only slightly so, averaging 40/100 ml.

TABLE IV

BACTERIOLOGICAL DATA SUMMARY
MARCH 1967

STATIONS	TOTAL COLIFORM*	FECAL COLIFORM*	NUMBER OF DETERMINATIONS
1A	150	80	2
1F	285	200	2
2	95	40	3
2B	250	165	2
3	140	50	2
3A	140	65	2
3B	215	120	1
3C	400	140	2
3E	130	65	3
3H	180	80	1
4	180	115	3
Water Plant	10	3	1

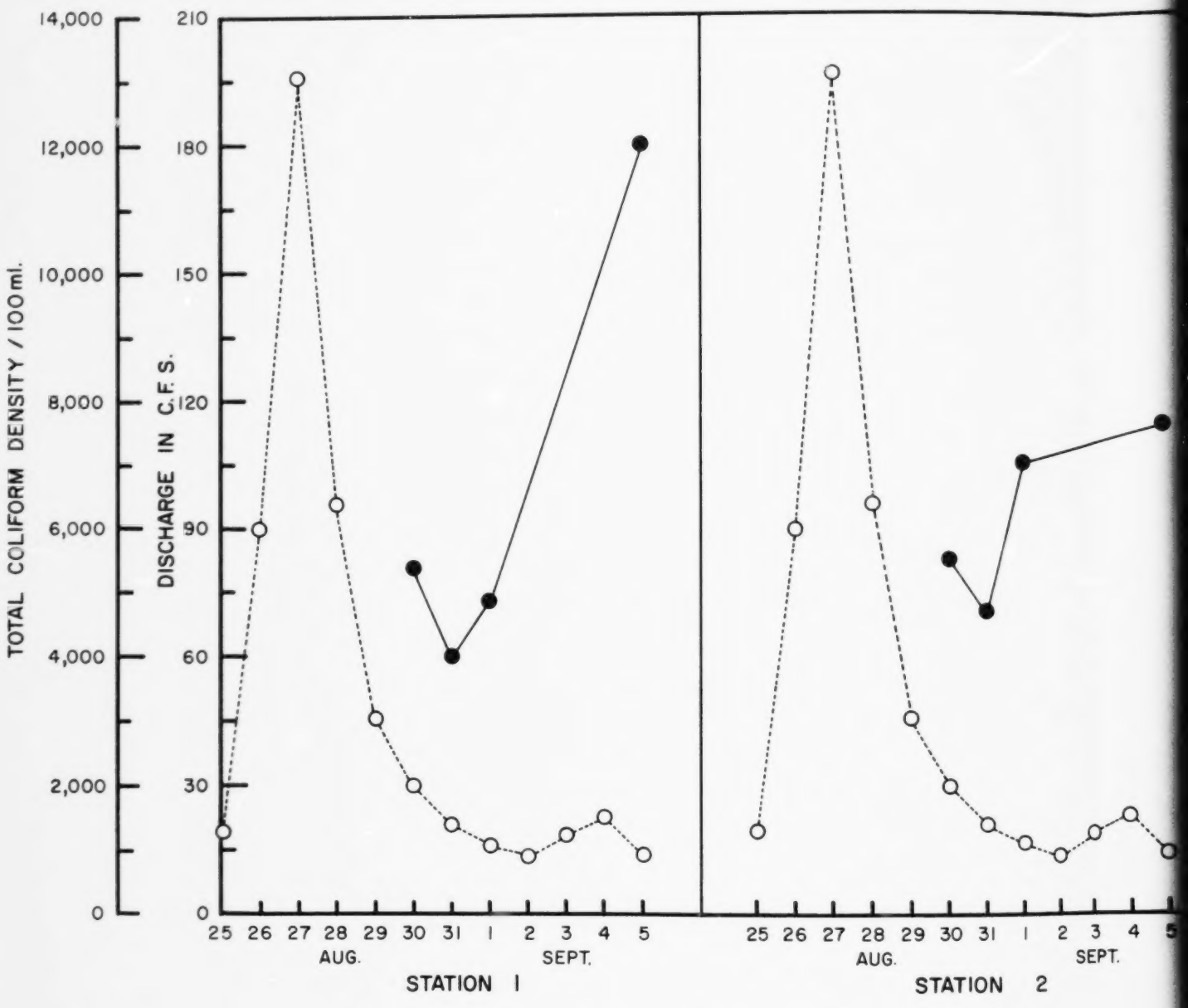
*Arithmetic mean where more than one determination was made.

TABLE V

BACTERIOLOGICAL DATA SUMMARY, AUGUST-SEPTEMBER 1967

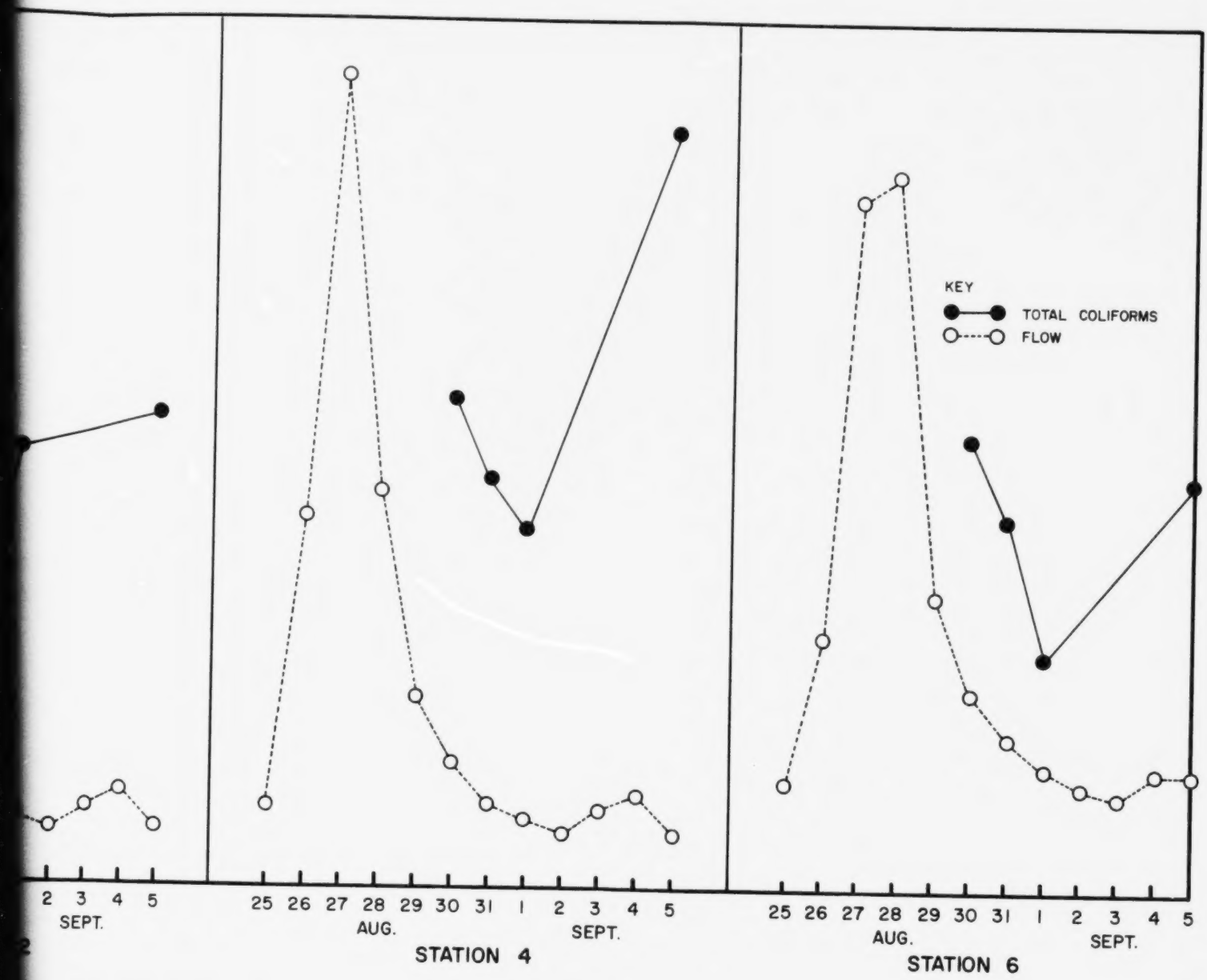
STATION	TOTAL COLIFORM*	FECAL COLIFORM*	NUMER OF DETERMINATIONS
1	10,000	140	2
1A	6,700	100	4
1F	6,100	85	2
1G	6,600	145	2
2	6,300	210	4
2A	19,000	780	2
2B	13,000	255	2
3	7,700	50	1
3 Left Bank	14,200	70	3
3 Right Bank	6,700	60	3
3A	9,500	150	4
3B	13,400	470	2
3C	6,400	95	4
3E	7,500	90	4
3F	17,200	305	2
3G	16,000	140	2
3H	14,200	80	1
4	8,300	140	4
4A	12,500	240	2
4B	11,800	60	2
5	10,400	180	2
6	6,100	70	4
Water Plant (Lake)	40	0	2

*Arithmetic mean where more than one determination was made.



RELATIONSHIP OF FLOW TO TOTAL CO
STATIONS DURING THE AUG

FIG

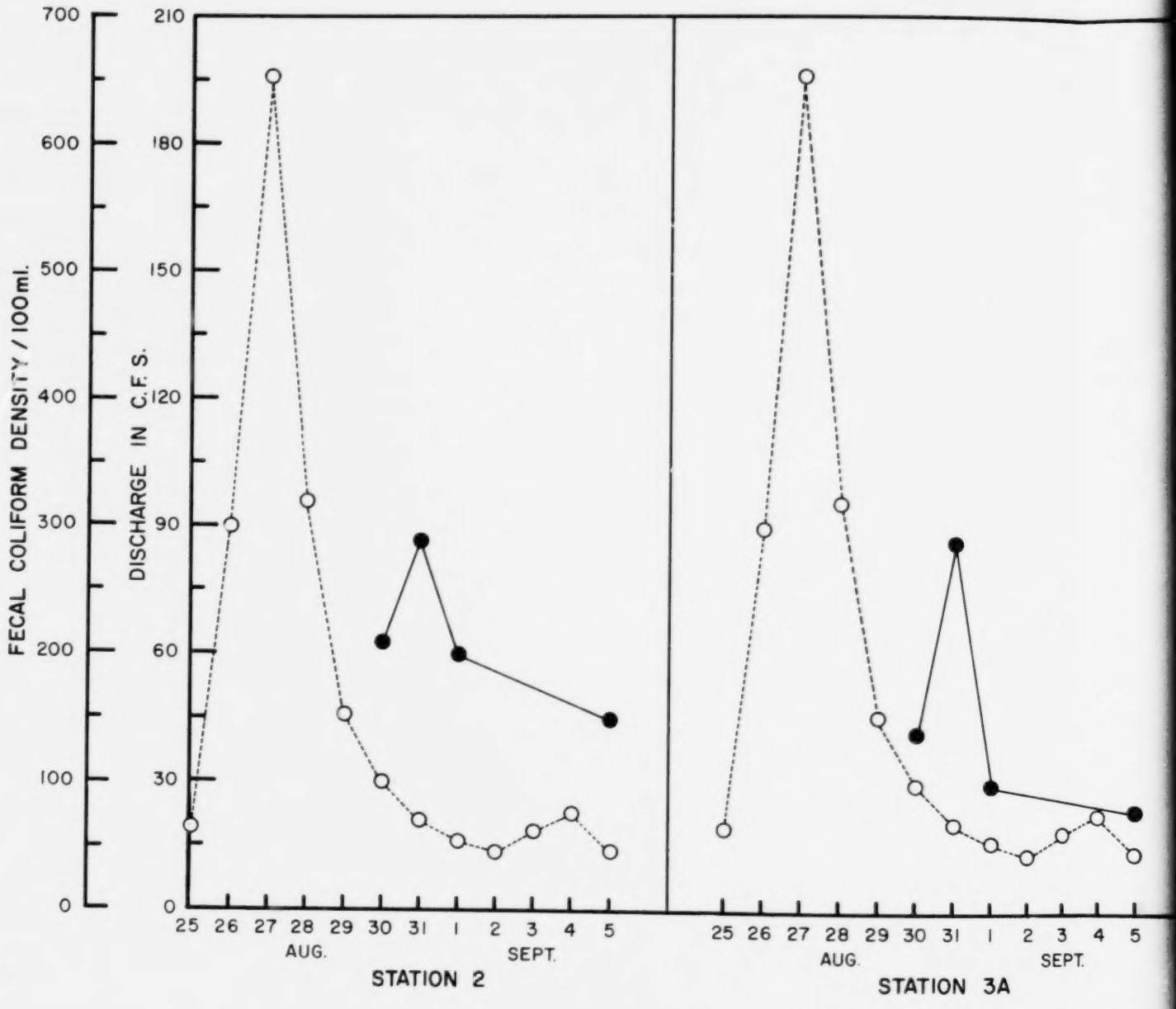


TOTAL COLIFORM DENSITY AT SELECTED MAIN STEM
G THE AUGUST - SEPTEMBER STUDY PERIOD

FIGURE 10

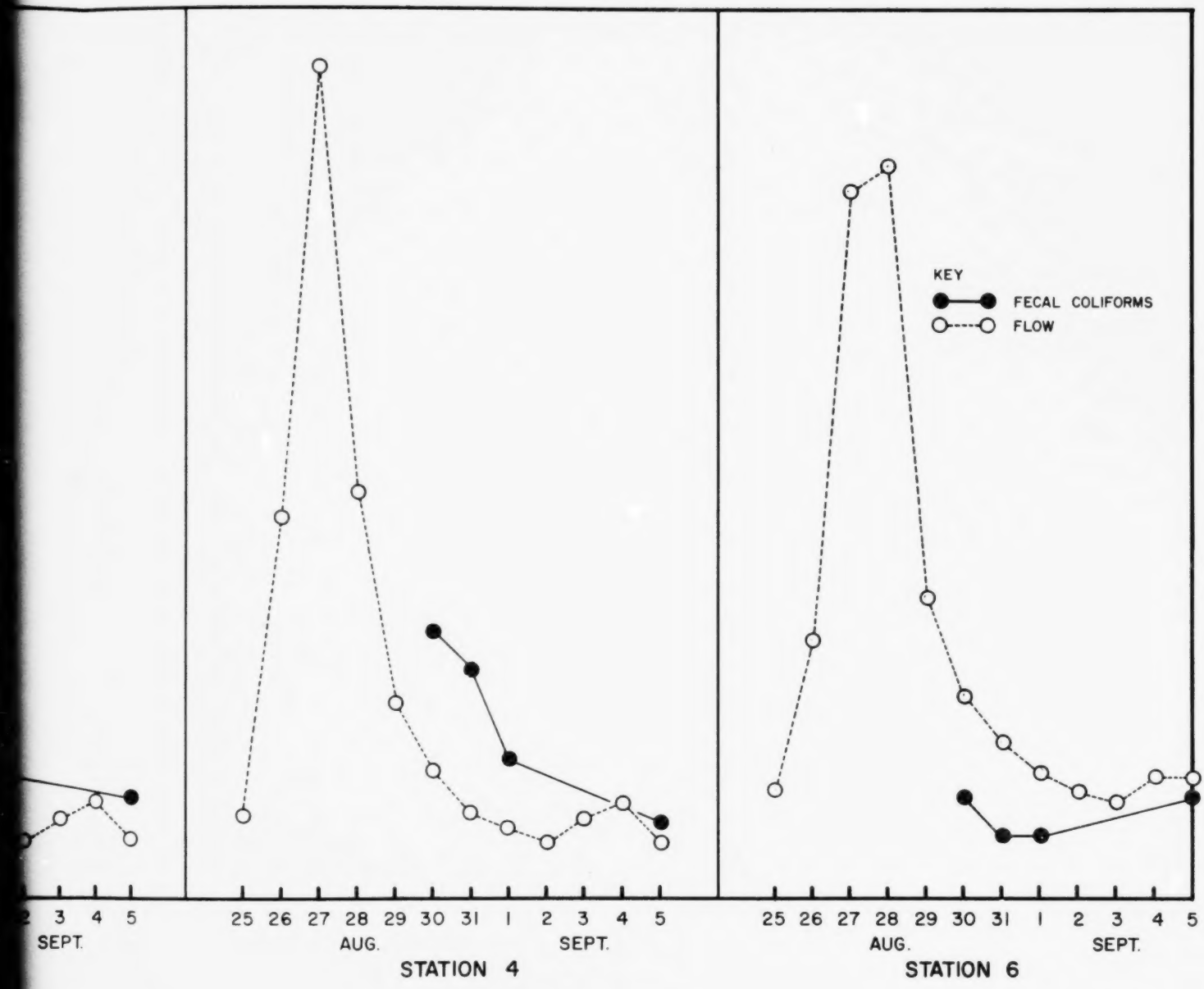
Fecal coliform data collected during both warm and cold weather survey periods are summarized in Tables IV and V. Fecal coliform counts ranged from an average of 50/100 ml at Station 2 to 200/100 ml at Station 1F during the March study and from 50/100 ml at Station 3 to 780/100 ml at Station 2A during the August-September survey. Fecal coliform levels such as these reflect a good overall bacteriological quality in the waters to be impounded. Elimination of some grazing areas during impoundment will further improve bacteriological quality. Fecal coliform counts did not respond to runoff in the August-September study as did total coliforms (Figure 11). This is another indication that fecal pollution sources are limited.

Figures 12 and 13 depict the relationship between average total and fecal coliform densities for the two 1967 study periods. Taken separately (different scales were used to depict relationships better), the figures show that fecal coliforms constituted a greater percentage of the total coliform count in March than in August-September. Since fecal coliform densities were similar for both surveys, it is possible that high runoff preceding the August-September survey introduced proportionately higher amounts of non-fecal coliform bacteria. Together, the two figures show relatively uniform bacterial quality in the watershed streams. Highest counts were observed in the smallest streams. A number of the stations with higher counts (1F, 2B, 2A, 3F, and 3G) were on very small tributaries with low flow at the time of sampling. In March, the total and fecal coliform densities on main stem stations in the reservoir watershed were slightly lower than on tributary streams in the watershed.



RELATIONSHIP OF FLOW TO FECAL COLIF
STATIONS DURING THE AUGUS

FIGU



FECAL COLIFORM DENSITY AT SELECTED MAIN STEM
THE AUGUST - SEPTEMBER STUDY PERIOD

FIGURE 11

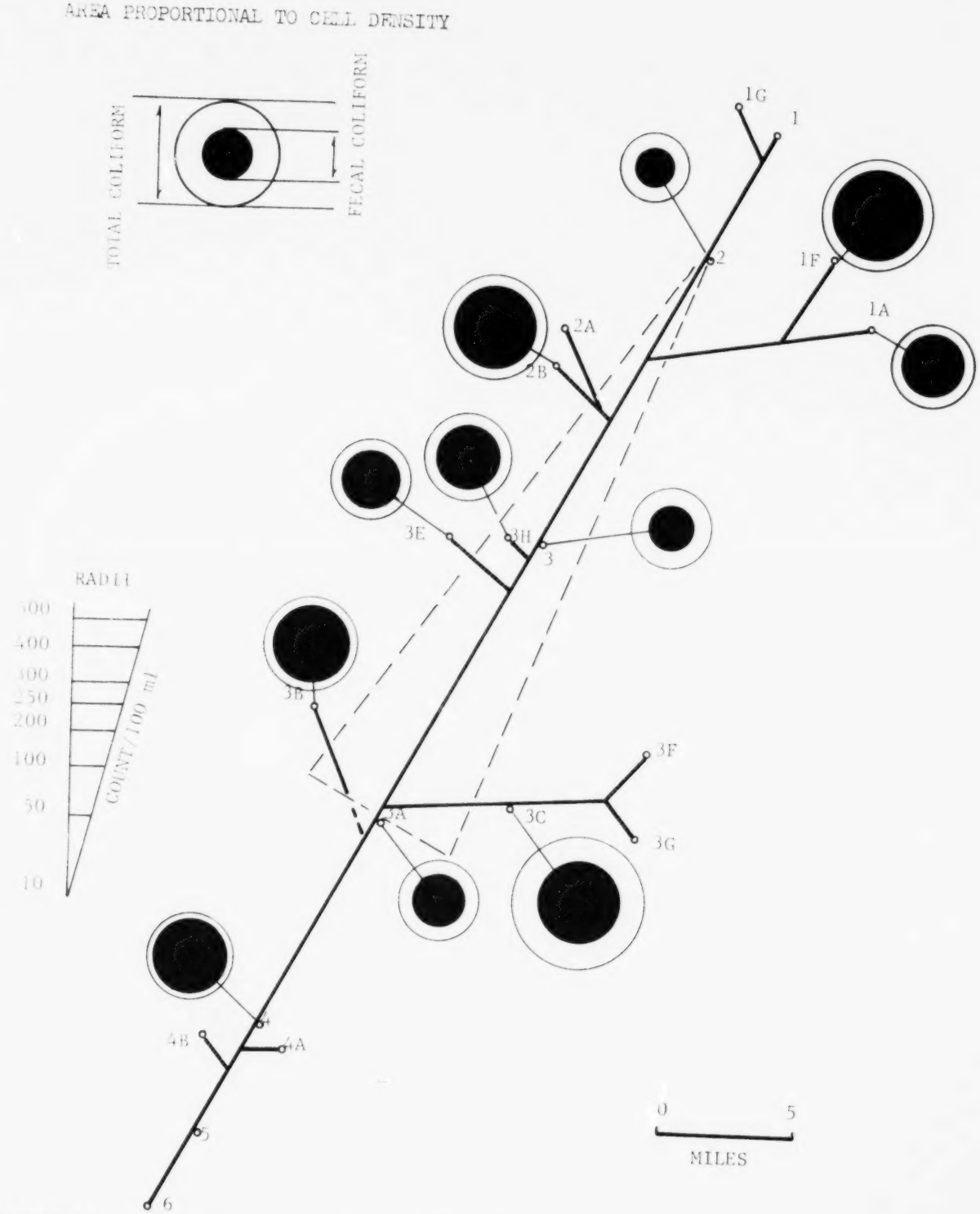


FIGURE 12. MEAN TOTAL AND FECAL COLIFORM DENSITIES AT EACH STATION DURING THE MARCH STUDY PERIOD.

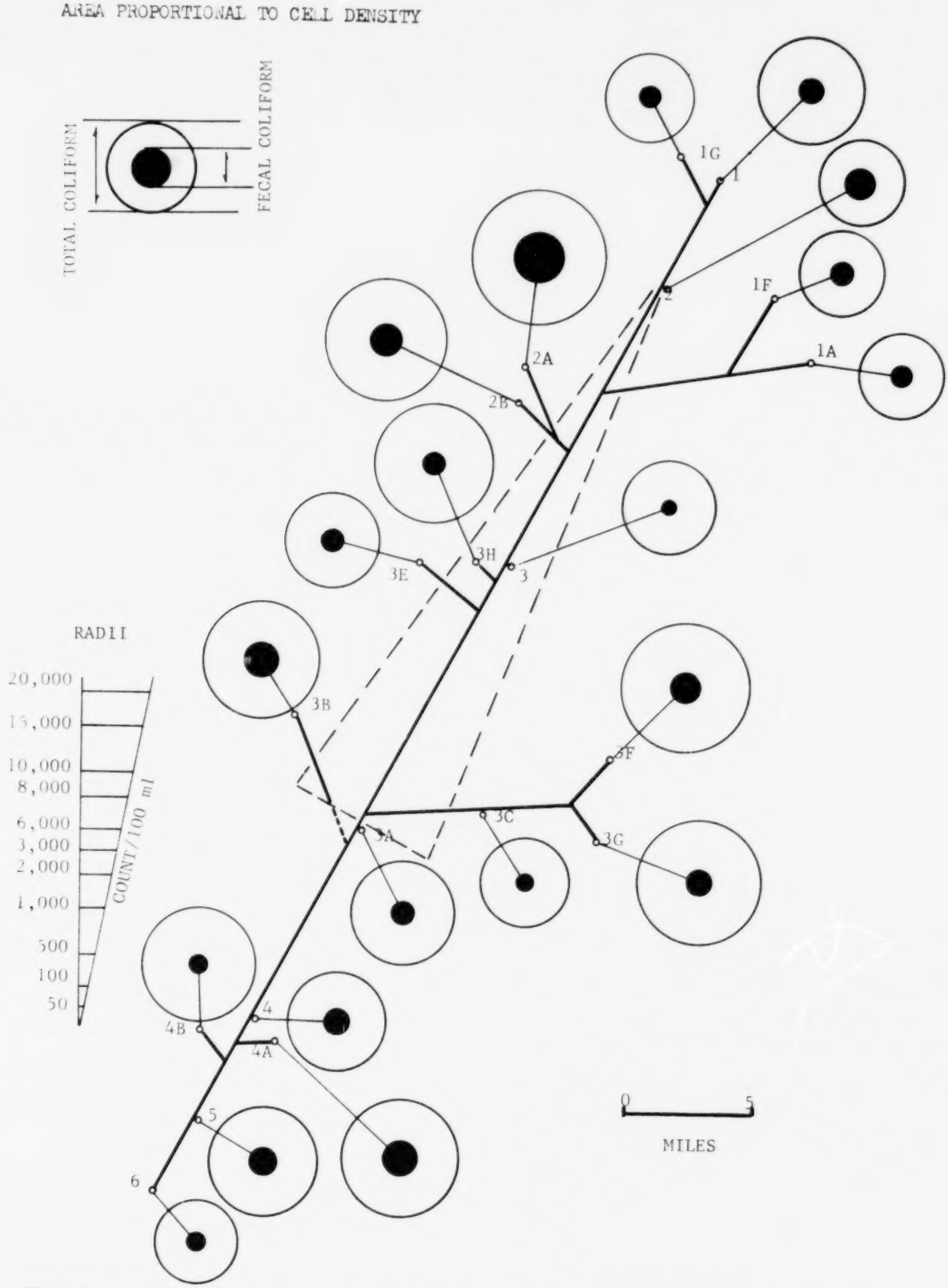


FIGURE 13. MEAN TOTAL AND FECAL COLIFORM DENSITIES AT EACH STATION DURING THE AUGUST-SEPTEMBER STUDY PERIOD.

Fecal streptococci[1] determinations were made during the August-September study only. Results of these determinations are summarized in Table VI. Average counts ranged from a high of 1,150/100 ml at Station 2A, where livestock were observed grazing, to a low of 50/100 ml at Stations 1F, 3, and 3G. Figure 14 shows the distribution of streptococci counts within the study area. Relatively higher counts at Stations 2A and 3F were associated with visual observations of grazing livestock.

The fecal coliform to fecal streptococci ratio has been suggested by Geldreich (9) as a means of differentiating between wastes of human and animal origin. Geldreich says that ratios greater than 4:1 indicate domestic pollution, while ratios of less than 0.6 indicate livestock and/or poultry waste. The importance of flow time from waste source to sampling point is recognized and presents a serious shortcoming to the ratio relationship. Ratios calculated for this study, realizing flow time importance, generally indicated predominately livestock, poultry, or wild animal waste sources in the watershed. The ratio values (Table VII) ranged from 0.0 to 2.6. Over half of the ratios were 1.0 or less.

Attempts to isolate Salmonella at several of the stations during the March and August-September study periods proved unsuccessful.

Substantial evidence of small game (raccoon, beaver, etc.) was present throughout the study area. The widespread distribution of these animals and their activities probably influenced the bacteriological picture at many of the stations.

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[1] Fecal Streptococci included the enterococcus group, Streptococcus mitis-salivarius group, S. bovis group, S. equinus group, and an atypical group that closely resembles the enterococcus group. But with one or more differences in critical biochemical tests.

TABLE VI

FECAL STREPTOCOCCI DENSITIES
DURING THE AUGUST-SEPTEMBER STUDY

STATION	ARITHMETIC MEAN *	NUMBER OF DETERMINATIONS
1	220	2
1A	100	3
1F	50	2
1G	290	2
2	80	3
2A	1,150	2
2B	310	2
3 Left Bank	60	3
3 Right Bank	50	3
3A	60	3
3B	225	1
3C	100	3
3E	90	3
3F	265	1
3G	50	1
3H	330	1
4	95	3
4A	290	2
4B	130	1
5	100	1
6	90	3
Water Plant	2	2

*Where more than one determination was made.

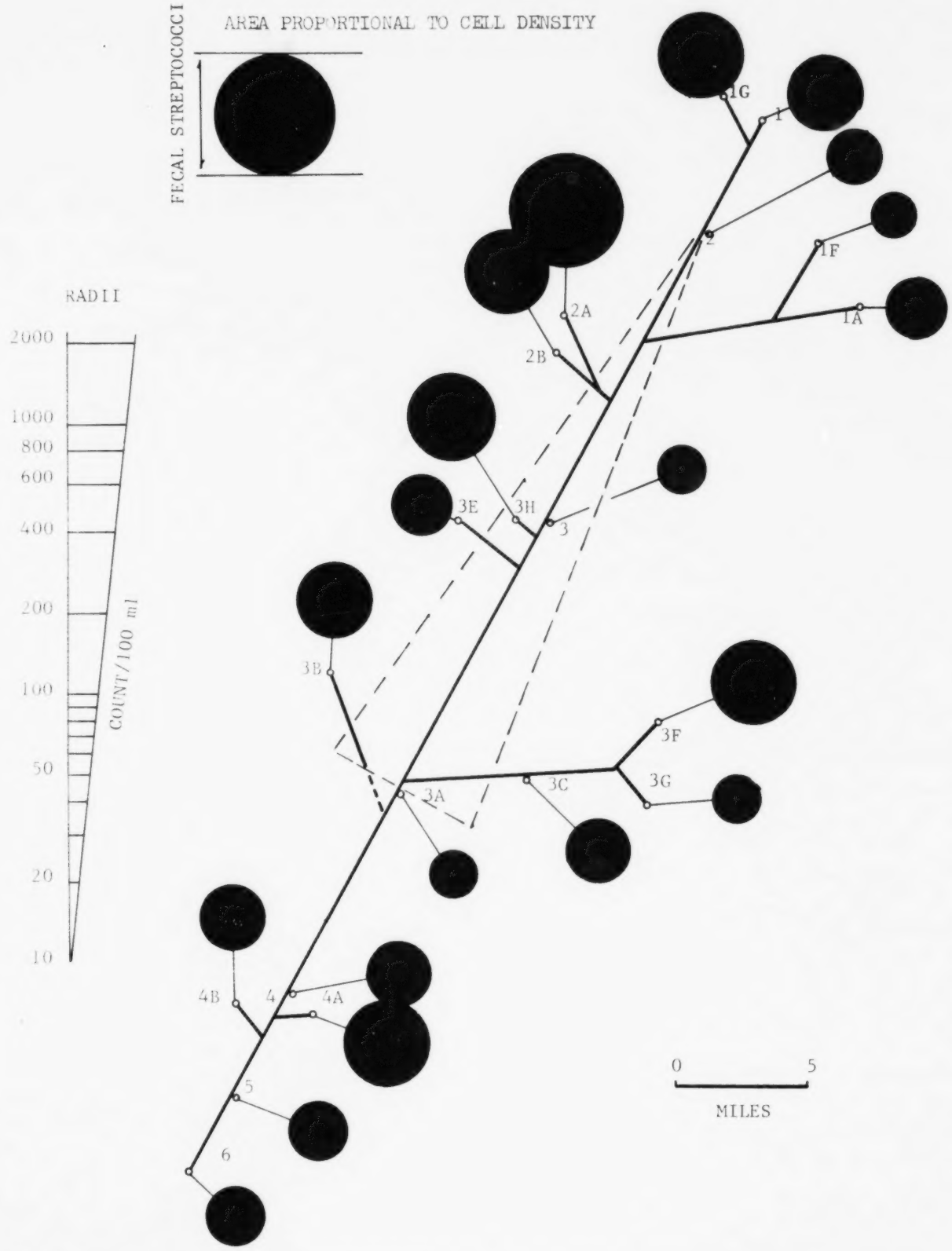


FIGURE 14. MEAN FECAL STREPTOCOCCI DENSITY AT EACH STATION DURING THE AUGUST-SEPTEMBER SAMPLING PERIOD.

TABLE VII

RATIO RELATIONSHIP BETWEEN FECAL COLIFORMS AND FECAL STREPTOCOCCI DURING THE AUGUST-SEPTEMBER STUDY

STATIONS	FC/FS
1	0.6
1A	0.9
1F	1.7
1G	0.5
2	2.6
2A	0.7
2B	0.8
3	-
3 Right Bank	1.4
3 Left Bank	1.0
3A	2.5
3B	1.8
3C	0.9
3E	1.0
3F	1.1
3G	2.5
3H	0.2
4	1.4
4A	0.5
5	1.3
6	0.7
Water Plant Intake (Lake)	0

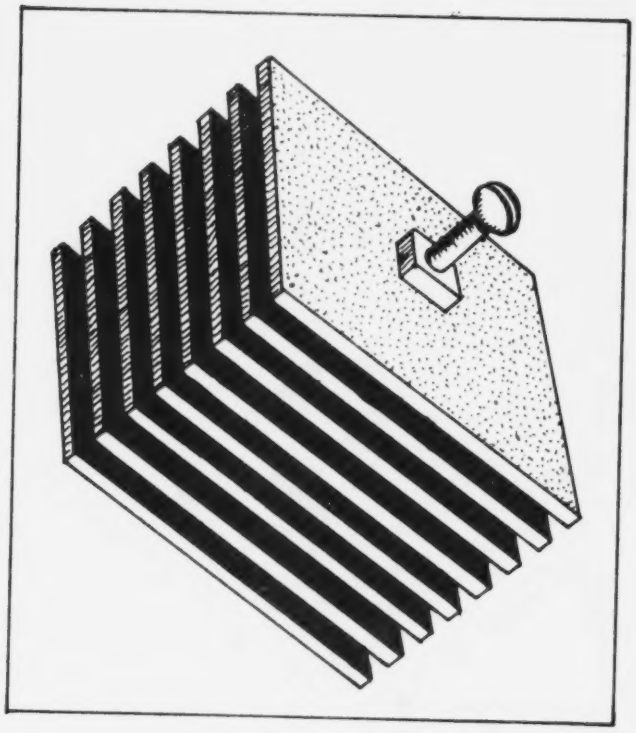
BIOLOGICAL WATER QUALITY

Sampling Methods

A biological survey of Okatibbee Creek and its major tributaries in the vicinity of Meridian, Mississippi, was conducted between September 11 and 15, 1967. The purpose of the investigation was to obtain a detailed record of preimpoundment biological conditions. Emphasis was given to the biology of: (a) the streams that will serve as influent water sources after the reservoir is filled, and (b) the main stem of Okatibbee Creek downstream from the dam. Sampling Stations 1, 1A, 2A, 2B, 4, 4A, 4B, 6, 7, 8, 9, and 10 were selected for the biological survey.

Multiple-plate samplers (Figure 15) to collect macro-invertebrates were submerged at each stream sampling station. After one month exposure to the aquatic environment, the community of invertebrates established on the plates was assumed to have attained an ecological equilibrium and, hence, to be representative of the invertebrate population as a whole. The sampling devices were recovered and the number of individuals of each species was recorded. Dipnet collections in each stream were made for additional qualitative data. Appendix E contains details concerning the biological techniques employed in this survey.

Plankton samples were collected from selected stations during the March survey.



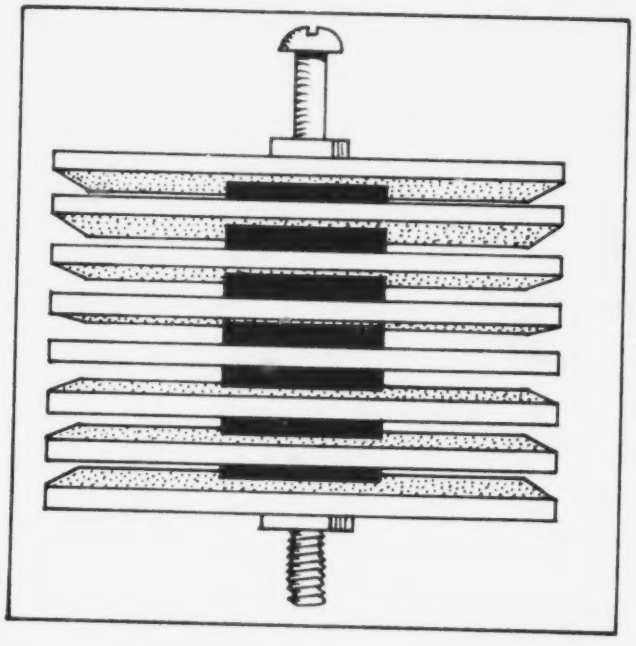


Figure 15 HESTER-DENDY MULTIPLE PLATE SAMPERS

Results

Two distinctly different biological communities existed in Okatibbee Creek in September 1967. Upstream from municipal and industrial wastes, i.e. all stations but Station 10, the creek's invertebrate population was dominated by immature insects. The multiple-plate samplers submerged for 30 days in this part of the study area provided niches for numerous species of gill-breathing insects. Most of the artificial substrata plates were covered with a thin layer of silt containing a healthy variety of midge larvae, beetle larvae, worms, crustaceans and mollusks (aquatic life forms which are sensitive to pollution). Net-building caddisfly larvae constructed shelters between plates, while nymphs of mayflies, damselflies, and stoneflies clung to the sides of the plates.[1/] The well-balanced invertebrate population at sampling points upstream from Station 10 is further exemplified by calculation of McIntosh diversity indices (10). The index value for each station is shown with interpretation in Table VIII. The difference between a polluted station (Station 10) and non-polluted ones is readily apparent.

Downstream from Meridian waste sources, Station 10, the invertebrate community was dominated by numerous tubificid worms and bloodworms. The multiple-plate samplers from this portion of Okatibbee Creek were completely coated by a slime growth, primarily a chain bacterium, Sphaerotilus. Intermingled in the slimy bacterial growth were numerous tubificids (Limnodrilus and Tubifex) and bloodworms (Chironomus stigmaterus). These organisms are considered tolerant to excessive organic enrichment and thrive in grossly

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[1/] For specific quantitative and qualitative distribution data, refer to the Appendix D.

TABLE VIII

McINTOSH DIVERSITY INDEX*

STATION	NUMBER OF SPECIES	NUMBER OF INDIVIDUALS/FT.^{2}	DIVERSITY
1	17	77	0.77
1A	21	61	0.84
2A	19	78	0.82
2B	24	108	0.74
4	18	56	0.83
4A	19	48	0.82
4B	18	53	0.82
6	19	49	0.85
7	19	52	0.74
9	15	37	0.80
10	6	77	0.41

* The index is $\sqrt{\sum_{i=1}^{S} n_i^2}$ where S equals the number of species and n equals the number of individuals in each species. An index value of 1.00 represents complete diversity while a value of 0.0 represents complete homogeneity.

polluted waters. Their presence in great numbers at Station 10 reflected gross organic pollution in this portion of Okatibbee Creek. Figure 16 illustrates the extent of the slime coverage on a Hester-Dendy sampler from Station 10 by comparing it with a sampler from an upstream station.

Plankton analyses for selected tributary and main stem sampling stations confirmed the absence of excessive algal growth. All total plankton counts were less than 500 per milliliter (predominately diatoms). In the absence of significant waste sources and with limited stream exposure to sunlight, it would be unusual to find excessive plankton production in the Okatibbee Creek watershed.

FIGURE 16 - COMPARISON OF A MULTIPLE-PLATE SAMPLER FROM STATION 9 (LEFT) WITH A SAMPLER FROM STATION 10 (RIGHT) SHOWING THE SPHAEROTILUS GROWTH STIMULATED BY MUNICIPAL AND INDUSTRIAL WASTES.

WATER QUALITY AND BIOLOGICAL CHANGES FOLLOWING IMPOUNDMENT

WATER QUALITY

Impoundment of the waters of Okatibbee Creek and its tributaries will effect significant changes in water quality. One of the classical results of impounding surface waters is to allow increased time for suspended solids to settle, which in turn results in generally lower turbidities over the long term. In addition, the increased detention time and sunlight exposure, along with other factors, will normally cause an increased rate of bacterial die-off to levels lower than those found in streams. This should produce acceptable bacterial levels within the lake for primary contact recreation, i.e. swimming and water-skiing.

Additional water quality benefits frequently attributed to impoundment include a smoothing of annual water quality variations and trapping of nutrients. The former is important from a water treatment standpoint, although it should be noted that except for suspended solids content, the waters within the reservoir watershed did not undergo severe quality fluctuations during the study period.

Nutrient losses [1/] anticipated between reservoir influent and effluent points reflect the various mechanisms by which natural eutrophication [2/] processes occur. If input nutrient levels are too high, nuisance biological problems can occur. No definite prediction can be made at this time as to the effect of existing nitrogen and phosphorus levels on Okatibbee Creek Reservoir. As noted previously, there is some indication that existing nitrogen and phosphorus concentrations could produce nuisance biological growth.

1/ Principally nitrogen and phosphorus.

2/ Eutrophication defined as the enrichment of lakes with nutrients.

However, it was also noted that the N and P levels found in the watershed were similar to those for other lakes in the Southeast in which nuisance growth problems were absent. With the limited extent of watershed development and lack of point source waste inputs which now exist, the potential for nuisance aquatic growth would appear to be at a minimum at this stage.

Mention of watershed development brings to light a precaution which should be observed. The Okatibbee Creek Reservoir has been partially cost justified on water supply and recreation bases. The Corps of Engineers, however, has only limited authority toward controlling the likely extensive watershed development, this control being necessary to protect water supply and recreational uses. Therefore, it behooves local and state planning authorities to insure that development will proceed with the view in mind that these uses be protected. This means adequate treatment of any domestic or industrial wastes which may be introduced into the watershed. Also, sources of nitrogen and phosphorus such as from municipal and industrial wastes and agricultural runoff should be held to a minimum. Within the reservoir proper, it will be advisable to promulgate regulations prohibiting waste discharges from watercraft.

Thermal stratification and its attendant water quality problem will almost certainly exist in Okatibbee Creek Reservoir, even though weather changes may upset this stratification at times during the warm weather months. The impoundment will be shallow (approximate normal pool depth of nine feet), but like the morphologically similar but larger Ross Barnett Reservoir near Jackson, Mississippi, there will be opportunity for thermal

layering during warm weather periods. As a consequence of stratification, it is expected that dissolved oxygen deficits and buildup of soluble iron and manganese will occur in hypolimetic waters. The present dam design permits low-level discharges into Okatibbee Creek which could create water quality problems.

Selective withdrawal intakes have been constructed in other reservoirs for municipal and industrial water supply withdrawal. These have been used successfully to overcome the stratification problems of hydrogen sulfide odor and excessive iron and manganese. Water withdrawn near reservoir surfaces during warm weather months will have higher temperatures than the bottom layers but will be of much better overall quality.

BIOLOGY

Many European and American scientists have studied biological succession in new reservoirs, and the available literature enables predictions to be made concerning changes in aquatic biota to be expected in Okatibbee Reservoir.

With an average summer time depth of nine feet, the reservoir will be fairly shallow. The lake shoreline will be gently sloping, hence, an extensive littoral zone will be present.

A typical history of the biological development of Okatibbee Creek Reservoir could be as follows:

> As the reservoir fills, terrestrial plants will be flooded and will die. The accumulating detritus will provide basic nutrients to help stimulate plankton development in the upper strata of the lake. Within a two-year period, plankton growth usually stabilizes to an acceptable level, i.e. unless external nutrient sources create accelerated eutrophication of the lake.
>
> Mud and fine loam deposits from runoff will begin to cover the lake floor as impoundment continues. The developing reservoir will, at first, be uncharacteristic of a lake. Drift organisms from

tributary streams will inhabit the reservoir. Some of these organisms will survive only a short time in the silt bottom deposits of the lake. Other drift organisms more tolerant of these lentic conditions will begin to establish new colonization along the shallow lake shoreline. Submerged vegetation will supply ample niches for various worms, crustaceans, mites, insects and their larvae (11). In the deeper open water, accumulating organic bottom materials will provide food and habitat for increasing numbers of midge larvae. According to Schneider (12), these insects are potential nuisance organisms and will eventually dominate the lake bottom.

The developing lake will undergo natural changes in fish population also. Stream species will be replaced by typical lake fish. Newly flooded areas, abundant with invertebrates, will supply vast feeding and spawning grounds for the fish. An initial increase in fish population will be reduced as fish-food and space become more limited and finally a reservoir ecosystem is established. With proper management, the fishery potential of the new reservoir is excellent.

Changes in the diverse biota of the tributary streams should be minor if it is assumed that development of the watershed will be limited in the future. In the lower flooded reaches of these streams, however, flow will be reduced and one can expect lentic species to gradually replace lotic forms. Other changes included an increased fish population as discussed above.

Biological changes downstream from the dam are the most difficult to predict. Previous work on reservoir tailwaters has dealt with high or low-water-level releases. On the benefit side, controlled releases from the reservoir will reduce the scouring of invertebrates (fish-food) which probably occurs now during high flow periods. However, there may be detrimental effects to the existing diverse, "clean stream" benthic biota and to existing fish life if low DO concentrations occur in release waters.

Water quality control releases from the reservoir are designed to improve biological conditions downstream from Meridian's waste discharges. Nevertheless, as long as the industrial complex continues to abuse Okatibbee Creek by discharging inadequately treated wastes, pollution will exist. The success of the Okatibbee Reservoir project in improving downstream biological conditions is dependent, therefore, on both:

(a) an adequate waste treatment program for existing and future waste sources in the Meridian area, and

(b) the release of water from the reservoir of a quality capable of supporting a healthy biological community (similar to that which now exists).

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(12) Schneider, Robert F., "Seasonal Succession of Certain Invertebrates in a Northwestern Florida Lake," Quarterly Journal Florida Academy of Science, 25, pp 127-141, (1962).

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APPENDIX A

REQUEST FOR STUDY AND FWPCA REPLY

U. S. ARMY ENGINEER DISTRICT, MOBILE
Corps Of Engineers
2301 Airport Boulevard
Mobile, Alabama

COPY

25 April 1966

Regional Program Director
Federal Water Pollution Control Administration
Room 404
50 Seventh Street, NE
Atlanta, Georgia 30323

Dear Sir:

It is requested that your agency prepare and furnish this office reports on pre-impoundment water quality conditions within the reservoir area and immediately downstream from the Okatibbee Dam on Okatibbee Creek near Meridian, Mississippi, and on the Alabama River from Montgomery to a point below the Claiborne Lock and Dam.

A previous report prepared by you for this office on water supply and dilution water requirements for pollution abatement in connection with the design of the Okatibbee Dam contains considerable water-quality data pertinent to a pre-impoundment survey for that project. However, this report does not mention several factors such as turbidity, color, algae count and others that it seems should be included in a complete pre-impoundment report. Also the previous report was based on data collected in November and December when water temperatures were generally low. The critical period from a water quality standpoint usually occurs during the period mid-August through early October when flows are low and water temperatures high and it is felt that additional sampling should be done during this period.

The closure at Okatibbee Dam is presently scheduled to be made in late summer of 1967, therefore if field data is to be obtained during the critical period it should be done during late summer or fall of this year. The closure at Millers Ferry Dam is scheduled to be made in November or December and field data for that portion of the Alabama River to be affected by this impoundment should also be obtained during the late summer or fall of this year. Closure at Claiborne Dam is presently scheduled for the summer of 1968 and at Jones Bluff Dam sometime in 1970. If time does not permit a complete survey of the Alabama River this year, the portions to be affected by Claiborne and Jones Bluff could be deferred.

COPY

SAMEN-PG
Regional Program Director

25 April 1966

Any comments or advice you may have concerning the scope of the surveys and contents of the reports would be appreciated. Also, please advise whether or not you feel that you can accomplish the field work within the time frame outlined above.

If this work can be done as requested please furnish estimates of cost of the pre-impoundment surveys and reports so that the necessary funds can be budgeted.

Sincerely yours,

B. J. CHRISTIANSEN
Chief, Planning and Reports Branch

UNITED STATES
DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

COPY

August 16, 1966

Your reference:
SAMEN-PG

District Engineer
U. S. Army Engineer District, Mobile
P. O. Box 1169
Mobile, Alabama 36601

Attention: Mr. B. J. Christiansen

Dear Mr. Christiansen:

In response to your request dated April 25, 1966, for a preimpoundment study at Okatibbee Reservoir near Meridian, Mississippi, we would furnish the following information. Warm weather studies can be initiated in the fall of 1966 (with a cold weather follow-up in winter of 1967) to characterize the water quality in the area of impoundment. Our personnel at the Southeast Water Laboratory in Athens, Georgia, will obtain the field data and complete the preimpoundment report by Summer, 1967.

Included in the study would be: (1) evaluation of all sources of waste in the impoundment watershed; agricultural, municiapl, etc., (2) analysis of bacteriological, chemical (including nutrients), biological, and physical parameters needed to describe the water quality, and (3) analysis of data and preparation of report.

The estimated cost for completion of this work is $12,500. It is requested that approval for initiation of this study be obtained as soon as possible in order that necessary staffing arrangements can be made.

Sincerely yours,

Herbert H. Rogers
Regional Program Director
Southeast Region

APPENDIX B

DESCRIPTION OF SAMPLING STATIONS

DESCRIPTION OF SAMPLING STATIONS

Station Number	Location
1	Okatibbee Creek - Lat. 32° 36' 12", long. 88° 0' 18"; in Sect. 26, T9N, R15E (Kemper County); at bridge on unimproved road, 5½ miles west of Mississippi Hwy. 493.
1A	Chickasawhay Creek - Bridge on gravelled road in Sect. 32, T9N, R15E (Kemper County); 2½ miles west of Prismatic community.
1F	Pender Creek - Bridge in southwest corner of Sect. 29, T9N, R15E (Kemper County); 3 miles west of Prismatic community; gravel road about one mile west of Station 1A. A small tributary.
1G	Houston Creek (or Calvert Branch of Little Creek) - Bridge on unimproved dirt road in Sect. 27, T9N, R14E (Kemper County); one mile west of Station 1.
2	Okatibbee Creek - Bridge gravelled road in Sect. 1, T8N, R14E (Lauderdale County).
2A	Hodge Branch tributary of House Creek - Bridge over small creek in Sect. 1, T8N, R14E (Lauderdale County); due north of Station 2B about ½ mile. A small tributary.
3	Okatibbee Creek - Bridge over newly paved road in Sect. 19, T8N, R15E (Lauderdale County); one mile east of county barn and two miles west of Joyner's Grocery.
3A	Okatibbee Creek - Main stem at dam site on line between Sects. 5 and 6, T7N, R15E (Lauderdale County).
3B	Twittley Branch - Bridge over recently built up roadway on line between Sect. 6 (R15E) and Sect. 1 (R14E), T7N (Lauderdale County). A small tributary.

DESCRIPTION OF SAMPLING STATIONS (CONT'D)

Station Number	Location
3C	Bales Creek - Downstream sampling station on new bridge and paved road in Sect. 33, T8N, R15E (Lauderdale County).
3E	Gin Creek - At new bridge and paved roadway in Sect. 24, T8N, R14E (Lauderdale County).
3F	Branch of Bales Creek - Bridge on paved road in Sect. 21, T8N, R15E (Lauderdale County); ¼ mile west of Joyner's Grocery and ½ mile west of Station 3G.
3G	Bales Creek - Upstream sampling point at bridge and paved road in Sect. 21, T8N, R15E (Lauderdale County); ¼ mile east of Joyner's Grocery.
3H	Unnamed Creek - Bridge on paved road in Sect. 19, T8N, R15E (Lauderdale County); 1/3 mile west of Station 3.
4	Okatibbee Creek - Bridge on paved road below dam in Sect. 16, T7N, R15E (Lauderdale County); Corps of Engineers stream gage at this point.
4A	Rogers Creek - Bridge on paved road in Sect. 16, T7N, R15E (Lauderdale County); 8/10 mile east of Station 4.
4B	Suqualena Creek - Bridge on Mississippi Hwy. 19 in Sect. 18, T7N, R15E (Lauderdale County).
5	Okatibbee Creek - Bridge on graded road in Sect. 28, T7N, R15E (Lauderdale County); 0.4 miles east of Hwy. 19 at stream mile 88.8.
6	Okatibbee Creek - Bridge on Mississippi Hwy. 19 in Sect. 4, T6N, R15E (Lauderdale County); one mile northwest of Meridian city limits.

DESCRIPTION OF SAMPLING STATIONS (CONT'D)

Station Number	Location
Meridian Water Plant (well)	Sampling point where well water enters settling basin.
Meridian Water Plant (lake)	Sampling point at tap on water plant grounds of water from city impoundments.

(Biological Sampling Only)

7	.....	Okatibbee Creek - Bridge at Old U. S. Hwy. 80 in Sect. 22, T6N, R15E (Lauderdale County); 4 miles upstream from Sowashee Creek confluence. USGS stream gage site.
8	.....	Okatibbee Creek - Bridge at U. S. Hwy. 80 in Sect. 22, T6N, R15E (Lauderdale County); 3.4 miles above Sowashee Creek confluence.
9	.....	Okatibbee Creek - Bridge on U. S. Hwy. 11 in Sect. 3, T5N, R15E (Lauderdale County); 0.9 miles above Sowashee Creek confluence.
10	.....	Okatibbee Creek - Bridge on graded county road in Sect. 3, T5N, R15E (Lauderdale County); 0.1 miles below Sowashee Creek confluence.

APPENDIX C

1963 PUBLIC HEALTH SERVICE STUDY WATER QUALITY DATA

APPENDIX C
SUMMARY OF SURVEY DATA

Sta. No.	Date	Time	Flow (cfs)	Diss. Oxygen (mg/l)	Temp (°C)	% Sat.	5 day BOD (mg/l)	pH	M.O. Alkalinity (mg/l $CaCO_3$)	Iron (mg/l)	Manganese (mg/l)	Chloride (mg/l)	Coli MPN/ 100 ml	Hardness (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Diss. Solids (mg/l)	Susp. Solids (mg/l)	Volatile Solids (mg/l)	Total Solids (mg/l)	Remarks
1	11/20/63	1045	-	7.0	14	67.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	11/20/63	1025	-	7.4	14	71.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/26/63		-	-	-	-	-	6.4	10	-	-	4	1,300	8.0	0.0	8.0	53	29	15	82	
	11/29/63		-	-	-	-	-	7.0	11	-	-	12	9,200	11.0	0.0	11.0	70	16	12	86	
	12/3/63		-	-	-	-	-	7.1	7	-	-	-	4,900	13.2	0.0	13.2	79	18	18	97	
	12/5/63		-	-	-	-	-	-	-	-	-	-	1,720	10.9	0.0	10.9	53	17	15	70	
	12/12/63		-	-	-	-	-	-	-	0.16	0.00	-	-	-	-	-	-	-	-	-	
3	11/20/63	1005	-	5.2	14.5	50.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
4	11/20/63	940	-	4.9	15	48.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/25/63	1150	-	7.9	12	73.1	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/26/63		-	-	-	-	-	6.8	20	-	-	-	1,300	16.4	0.0	16.4	40	21	15	61	
	11/29/63	920	-	7.7	11.5	70	4.2*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1320	-	9.0	12	83.5	-	7.3	-	-	-	-	16,000	12.4	0.0	11.0	62	20	16	82	
	12/2/63	815	-	9.7	9	84	5.3*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1245	-	9.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/3/63		-	-	-	-	-	6.8	13	-	-	-	24,000	14.2	0.0	14.2	64	19	19	83	
	12/5/63		-	-	-	-	-	-	-	-	-	-	1,300	13.2	0.0	13.2	60	12	12	72	
	12/12/63		-	-	-	-	-	-	-	0.16	0.00	-	-	-	-	-	-	-	-	-	
	12/14/63		-	-	-	-	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/16/63	910	-	12.4	2	89.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1415	-	12.5	4	93.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
5	11/20/63	920	-	4.9	14	47.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6	11/20/63	900	-	2.3	11	20.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
7	11/20/63	1135	-	7.0	16.5	71.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/25/63	1450	-	7.4	13.5	71.1	4.7	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/26/63		-	-	-	-	-	7.4	24	-	-	13	1,700	24.4	0.0	24.4	41	23	19	64	
	11/29/63	1015	-	7.7	13	72.5	5.1*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1350	-	7.0	14	67.5	-	7.4	22	-	-	15	92,000	20.4	2.0	18.4	100	133	30	233	
	12/2/63	845	-	9.3	9	80	3.1*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1315	-	9.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/3/63		-	-	-	-	-	7.2	18	-	-	-	3,300	19.4	0.0	19.4	63	20	20	83	
	12/5/63		-	-	-	-	-	-	-	-	-	-	1,410	14.8	0.0	14.8	64	20	18	84	
	12/12/63		-	-	-	-	-	-	-	0.21	0.00	-	-	-	-	-	-	-	-	-	
	12/14/63		-	-	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/15/63	1000	-	11.9	4	90.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1435	-	11.9	3	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/16/63	935	-	12.4	3	92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1435	-	12.4	4	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/17/63	1140	-	13.1	2	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1550	-	13.0	3	96.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/18/63	905	-	13.0	3	97.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1415	-	12.9	4	98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/19/63	1025	-	12.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
8	11/20/63	1200	3	8.8	18	92.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/25/63	1515	12	7.4	13.5	70.4	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/29/63	1055	-	8.8	13	83	2.1*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1430	14	8.8	13	83	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/2/63	935	-	9.3	9	80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1323	12	9.5	-	-	2.8*	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/10/63	1600	-	10.7	6	86	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1210	12	10.6	7	87	2.2*	-	-	-	-	-	-	-	-	-	-	-	-	-	

SUMMARY OF SURVEY DATA

Sta. No.	Date	Time	Flow (cfs)	Diss. Oxygen (mg/l)	Temp (°C)	% Sat.	5 day BOD (mg/l)	pH	M.O. Alkalinity (mg/l $CaCO_3$)	Iron (mg/l)	Manganese (mg/l)	Chloride (mg/l)	Coli MPN/100 ml	Hardness (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Diss. Solids (mg/l)	Susp. Solids (mg/l)	Volatile Solids (mg/l)	Total Solids (mg/l)	Remarks
8 (cont'd)	12/16/63	950	-	12.2	3	92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1450	45	12.5	3	93.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/17/63	1130	-	12.8	3	95	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1540	-	13.0	3	97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/18/63	935	-	13.0	3	97.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1400	-	12.9	4	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
9	11/20/63	1430	-	6.0	16	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/26/63		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/29/63	820	-	8.0	13	85.5	-	7.8	30	-	-	12	13,000	27.6	0.0	27.6	41	26	15	67	
		1335	-	8.2	13	77.5	3.1*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1645	-	8.1	13	76.5	-	7.1	25	-	-	22	-	23.6	0.0	23.6	95	94	29	189	
	12/3/63		-	-	-	-	-	7.1	21	-	-	-	490	22.0	3.0	19.0	76	27	23	103	
	12/5/63		-	-	-	-	-	-	-	-	-	-	1,720	-	-	-	-	-	-	-	
	12/12/63		-	-	-	-	-	-	-	0.21	0.00	-	-	-	-	-	-	-	-	-	
	12/16/63	1100	-	12.0	4	91.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1625	-	12.4	4	94.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/17/63	1100	-	12.0	4	91.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1625	-	12.4	4	94.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
10	11/20/63	1445	-	0.0	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/25/63	1545	-	0.9	17	9.3	72	-	-	-	-	-	-	-	-	-	-	-	-	-	
	11/26/63		-	-	-	-	-	7.7	74	-	-	-	-	-	-	-	-	-	-	-	
	11/29/63	800	-	4.8	14	46	-	-	-	-	-	59	1,300,000	57.4	22.6	34.8	244	54	41	298	
		1315	-	5.6	14	54	14*	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1710	-	5.4	14	52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/2/63	735	-	6.2	10	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1045	-	6.1	11.5	55.5	33*	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/3/63		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/5/63		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/10/63	1105	-	6.0	8	50	20*	-	-	-	-	-	79,000	-	-	-	-	-	-	-	
		1315	-	6.1	9	52	-	-	-	-	-	-	1,600,000	-	-	-	-	-	-	-	
	12/12/63		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/15/63	1000	-	9.7	4.5	75.5	-	-	-	0.34	0.00	-	-	-	-	-	-	-	-	-	
		1450	-	10.2	6	81.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/16/63	850	-	10.2	4	77.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1400	-	10.4	5.5	82.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/17/63	935	-	10.0	3.5	77.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		1410	-	10.0	6.5	81	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/18/63	1420	-	8.9	7.5	74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	12/19/63	1120	-	9.3	4	71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

* - Composite

APPENDIX D

1967 WATER QUALITY DATA

TABLE D-1
MARCH 1967 SURVEY DATA SUMMARY

STATION NUMBER	pH		TEMPERATURE (°C)		CONDUCTIVITY (μmhos)		COLOR (Units)		HARDNESS (mg/l as $CaCO_3$) Total		Ca		CHLORIDE (mg/l)		ALKALINITY (mg/l as $CaCO_3$)	
	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L
1-A	7.0/4	7.1/6.8	15.8/4	19.0/12.0	73/4	82/65	73/4	90/60	20.7/4	23.8/18.6	6.4/4	7.8/4.8			19.6/4	20.0/19.0
1-F	6.7/2	6.7/6.6	16.0/2	19.0/13.0	56/2	57/55	85/2	100/70	19.5/2	19.6/19.4	4.2/2	6.4/2.0			16.2/2	17.0/15.5
2	6.9/4	7.2/6.7	15.9/4	19.0/12.5	60/4	62/55	70/4	80/60	18.8/5	24.8/15.8	4.7/5	6.2/2.6			16.6/5	21.0/14.0
2-B	7.0/2	7.0/7.0	14.5/2	19.0/10.0	55/2	55/54	80/2	90/70	15.0/2	17.4/12.6	3.0/2	3.2/2.8			14.5/2	15.0/14.0
3	7.1/2	7.3/6.9	13.8/2	14.0/13.5	71/2	72/70	78/2	95/60	19.1/2	20.0/18.2	5.5/2	5.6/5.4			22.0/2	26.0/18.0
3-A	6.9/3	7.1/6.6	15.0/3	19.0/13.0	72/3	75/70	67/3	95/45	21.0/3	23.2/17.8	6.4/3	8.4/5.0			18.6/3	21.0/17.0
3-B	6.8/2	6.9/6.7	15.0/2	20.0/10.0	56/2	57/54	95/2	110/80	15.1/2	15.2/15.0	3.9/2	4.2/3.6	6.5/2	6.5/6.5	17.5/2	18.0/17.0
3-C	6.9/3	7.0/6.7	14.5/3	19.5/12.0	81/3	98/65	82/3	95/70	23.0/3	26.8/19.8	9.4/3	12.2/5.6	8.5/1		21.0/3	26.0/15.0
3-E	7.0/4	7.3/6.6	15.5/4	20.0/11.0	66/4	80/60	93/4	105/80	21.6/4	26.8/16.4	6.8/4	9.2/4.6	7.0/2	7.5/6.5	17.0/4	22.0/14.5
3-H	7.2/2	7.5/6.8	19.5/2	20.0/19.0	58/2	60/55	72/2	90/55	19.2/2	21.8/16.6	6.3/2	8.4/4.2			18.5/2	20.5/16.5
4	7.0/4	7.2/6.8	16.8/4	19.0/14.0	67/4	73/64	88/4	100/80	20.7/4	31.2/11.8	5.5/4	7.0/4.2	7.5/2	8.0/70	18.3/4	19.5/17.0
6	6.6/1		12.0/1		65/1		80/1		18.0/1		6.0/1		8.01		18.0/1	
Water Plant (Well)	6.9/1		18.0/1		240/1		0/1		18.8/1		7.6/1		16.5/1		78.5/1	
Water Plant (Lakes)	6.7/1				40/1		20/1		6.6/1		0/1		5.5/1		6.5/1	

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = highest value
L = lowest value

TABLE D-1 (Contd.)
MARCH 1967 SURVEY DATA SUMMARY

STATION NUMBER	TOTAL IRON (mg/l)		TOTAL MANGANESE (mg/l)		KJELDAHL-N (mg/l)		NITRATE-N (mg/l)		AMMONIA- (mg/l)	
	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	
1-A	1.76/2	2.23/1.29	0.18/2	0.19/0.17	0.42/2	0.45/0.39	0.47/2	0.53/0.42	0.07/2	0.
1-F					0.78/1		0.27/1		0.07/1	
2	2.49/3	2.57/2.32	0.17/3	0.19/0.14	0.64/2	0.78/0.51	0.35/2	0.44/0.27	0.08/2	0.
2-B	2.44/1		0.21/1							
3	2.53/1		0.21/1		0.50/1		0.38/1		0.06/1	
3-A	2.53/1		0.19/1		0.67/2	0.67/0.67	0.45/2	0.53/0.38	0.07/2	0.
3-B	3.41/2	4.51/2.57	0.44/2	0.47/0.41	0.62/1		0.42/1		0.07/1	
3-C	2.74/2		0.21/1		0.95/2	1.01/0.89	0.34/2	0.42/0.27	0.07/2	0.
3-E	2.96/3	3.04/2.92	0.16/3	0.17/0.14	0.72/2	0.95/0.50	0.48/2	0.53/0.44	0.14/2	0.
3-H	2.57/1		0.69/1		0.78/1		0.27/1		0.07/1	
4	2.40/2	2.66/2.14	0.13/2	0.14/0.12	0.56/2	0.73/0.40	0.34/2	0.42/0.27	0.06/2	0.
6	2.66/1		0.19/1		0.78/1		0.46/1		0.08/1	
Water Plant (Well)										
Water Plant (Lakes)										

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = highest value
L = lowest value

LE D-1 (Contd.)
VEY DATA SUMMARY

AMMONIA-N (mg/l)		PHOSPHATE (as P) TOTAL (mg/l)		PHOSPHATE (as P) ORTHO (mg/l)		SULFATE		TOTAL COLIFORM (No./100 ml)		FECAL COLIFORM (No./100 ml)	
Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L
0.07/2	0.07/0.07	0.05/2	0.05/0.05	0.03/2	0.03/0.02	14.4/4	18.5/9.4	150/2	180/120	80/2	110/45
0.07/1		0.03/1		0.03/1		18.1/2	20.1/16.2	285/2	290/285	200/2	245/150
0.08/2	0.10/0.06	0.03/2	0.05/0.02	0.03/2	0.04/0.02	12.6/4	16.3/10.1	95/3	120/70	40/3	60/40
						12.6/2	16.5/ 8.7	250/2	360/140	165/2	180/150
0.06/1		0.02/1		0.02/1		15.3/2	15.7/14.9	140/2	170/100	50/2	64/40
0.07/2	0.07/0.06	0.04/2	0.06/0.03	0.03/2	0.05/0.02	21.2/3	32.7/15.2	140/2	150/130	65/2	70/60
0.07/1		0.04/1		0.02/1		10.1/2	13.7/ 6.6	215/1		120/1	
0.07/2	0.07/0.06	0.05/2	0.05/0.05	0.03/2	0.05/0.02	21.9/3	28.4/12.9	400/1		140/2	200/75
0.14/2	0.14/0.13	0.03/2	0.04/0.03	0.02/2	0.03/0.02	19.8/4	25.4/14.2	130/3	170/70	65/3	110/30
0.07/1		0.03/1		0.03/1		9.0/2	11.7/6.4	180/1		80/1	
0.06/2	0.07/0.05	0.03/2	0.04/0.02	0.03/2	0.03/0.03	11.5/4	16.8/8.1	180/3	265/100	115/3	150/83
0.08/1		0.02/1		0.02/1		8.6/1					
						9.7/1					
						7.4/1					

TABLE D-1 (Contd.)
MARCH 1967 SURVEY DATA SUMMARY

STATION NUMBER	DISSOLVED OXYGEN (mg/l)		DISSOLVED OXYGEN (% Saturation)		B O D (mg/l)		C O D	S O L I D S							
								TOTAL (mg/l)		SUSPENDED (mg/l)		DISSOLVED (mg/l)		VOLATILE (mg/l)	
	Avg.	H/L	Avg.	H/L	2 Day	5 Day	(mg/l)	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L
1-A	8.8/4	9.5/8.0	88/4	90/85	1.6/1	2.4/1	19.4/1	84/4	92/75	17/4	22/12	67/4	73/54	6/4	10/4
1-F	7.3/2	7.4/7.2	74/2	77/70	1.2/1	2.3/1		89/2	92/86	28/2	31/25	61/2	61/61	7/2	7/7
2	8.6/4	9.4/7.8	86/4	88/83	0.5/1	1.0/1	19.4/1	77/4	86/71	20/4	27/15	58/4	69/46	10/4	22/4
2-B	9.1/2	9.5/8.7	89/2	93/84	0.5/1	1.1/1		76/2	77/75	27/2	37/17	49/2	60/38	13/2	20/6
3	8.5/2	9.0/8.1	82/2	86/78	1.2/1	1.7/1	18.5/1	74/2	74/73	13/2	14/11	61/2	63/59	5/2	6/4
3-A	8.5/3	8.9/8.1	83/3	86/79	0.7/1	1.0/1	14.1/1	87/3	95/82	20/3	27/17	63/3	78/58	7/3	11/4
3-B	10.6/2	11.7/9.5	108/2	113/103			18.5/1	93/2	98/87	30/2	33/26	63/2	65/61	11/2	17/5
3-C	9.0/3	10.3/8.2	88/3	95/81	0.6/1	1.1/1	6.3/1	97/3	103/87	26/3	34/15	71/3	73/68	10/3	15/6
3-E	8.3/4	9.5/7.7	83/4	86/77	1.3/1	3.4/1	12.5/1	95/4	104/79	21/4	29/9	74/4	84/69	8/4	11/2
3-H	6.4/2	6.5/6.2	68/2	69/67				76/2	76/75	17/2	17/16	59/2	60/58	10/2	10/9
4	8.6/4	9.5/7.7	87/4	91/82	0.5/1	1.2/1	14.3/1	74/4	77/63	16/4	19/11	58/4	64/47	7/4	9/5
6	9.1/1		84/1				14.1/1	80/1		14/1		66/1		5/1	
Water Plant (Well)								102/1		10/1		92/1		6/1	
Water Plant (Lakes)								48/1		7/1		41/1		5/1	

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = highest value
L = lowest value

TABLE D-2
AUGUST-SEPTEMBER, 1967 SURVEY DATA SUMMARY

STATION NUMBER	pH		TEMPERATURE (°C)		TURBIDITY (Jackson Candle Units)	CONDUCTIVITY (μmhos)	COLOR (Units)		TOTAL HARDNESS (mg/l as $CaCO_3$)		CHLORIDE (mg/l)		ALKALINITY (mg/l as $CaCO_3$)	
	Avg.	H/L	Avg.	H/L		Avg.	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L
1	7.2/3	7.4/7.0	20/3	21/19	<25	43/1	45/1		18/3	20/14	7.7/3	8.6/6.0	13/3	15/11
1-A	7.2/5	7.3/7.0	20/5	21/19	<25	52/1	73/2	90/55	18/6	22/16	8.3/6	15.7/5.0	19/6	21/12
1-F	7.2/5	7.3/7.0	22/5	26/19	<25- 30	55/1	60/1		22/4	26/18	7.7/4	11.7/5.0	20/4	24/17
1-G	7.2/3	7.3/6.9	20/3	21/20	<25	45/1	70/1		19/3	22/16	7.5/3	9.3/6.0	17/3	19/15
2	7.2/5	7.4/6.9	20/5	22/19	<25	41/1	78/2	100/55	17/6	24/14	9.8/6	14.7/6.0	14/6	16/11
2-A	7.2/4	7.3/7.1	22/4	24/19	<25	29/1	35/1		15/3	24/10	7.0/3	9.0/4.0	9/3	10/7
2-B	7.1/4	7.4/6.9	21/4	22/19	<25	32/1	25/1		15/3	16/14	6.4/3	9.0/4.0	12/3	14/9
3-Right Bank	7.2/5	7.3/7.1	21/5	23/20	<25	42/1	90/2	120/60	20/6	26/14	10.9/6	16.3/5.0	14/6	16/10
3-Left Bank	7.1/3	7.4/6.8	22/3	23/21	<25- 400		110/1		21/3	28/14	6.0/3	10.2/1.9	14/3	19/7
3-A	7.1/4	7.3/6.9	22/4	24/19	<25- 32	44/1	95/2	130/60	18/5	24/12	14.3/5	17.6/5.0	16/5	25/7
3-B	7.1/4	7.2/6.9	22/5	29/19	<25- 33	58/1	50/1		25/4	28/21	6.0/4	12.7/2.2	20/4	27/14
3-C	7.3/5	7.4/7.2	21/5	23/19	<25	58/1	90/2	110/70	24/6	28/19	11.7/6	20.4/4.0	21/6	26/11
3-E	7.2/5	7.3/7.1	21/5	22/20	<25	45/1	75/2	80/70	25/5	34/16	9.9/5	15.2/5.0	16/5	18/5
3-F	7.2/4	7.4/7.1	21/4	23/19	<25- 28	67/1	90/1		32/4	36/24	12.9/4	25.2/5.0	25/4	31/14
3-G	7.1/4	7.3/6.9	21/4	23/19	<25- 34	53/1	80/1		21/4	24/18	7.8/4	24/16	21/4	24/16
3-H	7.3/1		20/1		<33				52/1		5.0/1		40/1	
4	7.2/5	7.3/7.0	21/5	23/19	<25- 190	42/1	85/2	120/50	19/6	24/14	9.5/6	17.7/4.0	16/6	20/12
4-B	7.1/4	7.3/6.9	21/4	23/19	<25- 28				23/4	30/18	6.5/4	14.6/5.0	19/4	27/14
4-A	7.3/1		22/1		<25				18/1		16.7/1		18/1	
5	7.1/4	7.4/6.5	21/4	24/20	<25- 140	43/1	60/1		20/4	24/14	9.1/4	20.6/5.0	18/4	24/13
6	7.2/5	7.4/6.9	22/5	23/20	<25- 28	43/1	90/2	110/70	17/5	20/14	14.2/5	22.9/6.0	13/5	17/14
Water Plant (Lakes)					<25	26/1	15/1		14/1		5.0/1		8/1	

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = highest value
L = lowest value

TABLE D-2 (Contd.)
AUGUST-SEPTEMBER, 1967 SURVEY DATA SUMMARY

STATION NUMBER	DISSOLVED OXYGEN (mg/l)		DISSOLVED OXYGEN (% Saturation)		BOD_5 (mg/l)	SOLIDS		
	Avg.	H/L	Avg.	H/L		TOTAL (mg/l)	DISSOLVED (mg/l)	SUSPENDED (mg/l)
1	7.8/2	7.9/7.6	84/2	88/81	0.5/1	103/1	92/1	11/1
1-A	7.2/5	8.0/6.6	76/5	89/72	0.3/1	82/1	73/1	9/1
1-F	2.4/4	3.0/1.9	28/4	34/20	0.8/1	87/1	57/1	30/1
1-G	6.5/3	7.2/6.1	72/2	78/66	0.6/1	50/1	41/1	9/1
2	7.4/5	7.7/7.1	82/5	86/78	0.8/1	76/1	71/1	5/1
2-A	8.3/3	8.7/7.6	91/3	100/84	0.6/1	79/1	64/1	15/1
2-B	7.6/3	8.3/6.7	84/3	93/71	1.3/1	66/1	57/1	9/1
3-Right Bank	6.9/5	7.8/6.6	76/5	90/72	0.4/1	79/1	75/1	4/1
3-Left Bank	6.5/3	7.6/5.4	74/3	88/60				
3-A	6.7/4	7.1/6.5	78/4	84/72	0.7/1	157/1	143/1	14/1
3-B	8.2/3	8.8/7.5	90/3	100/80	0.6/1	80/1	73/1	7/1
3-C	5.6/5	6.9/5.1	63/5	80/54	0.9/1	120/1	114/1	6/1
3-E	6.8/5	7.1/6.4	76/5	81/70	0.7/1	82/1	75/1	7/1
3-F	4.8/3	5.4/4.5	53/3	59/48	1.1/1	68/1	50/1	18/1
3-G	3.3/3	3.8/2.8	39/3	42/35	0.3/1	143/1	124/1	19/1
3-H	4.3/1		47/1					
4	6.9/5	7.2/6.4	76/5	82/71	0.7/1	175/1	146/1	29/1
4-B	2.9/3	3.2/2.7	32/3	34/30	0.4/1	108/1	77/1	31/1
4-A	7.9/1		90/1					
5	6.5/3	6.5/6.5	71/3	72/70	1.3/1	99/1	72/1	27/1
6	6.8/4	7.2/6.5	78/4	83/74	0.6/1	103/1	81/1	22/1
Water Plant (Lakes)	7.4/1							

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = highest value
L = lowest value

TABLE D-2 (Contd.)
AUGUST-SEPTEMBER, 1967 SURVEY DATA SUMMARY

STATION NUMBER	TOTAL IRON (mg/l)		TOTAL MANGANESE (mg/l)		KJELDAHL-N (mg/l)		NITRATE-NITRITE-N (mg/l)		AMMONIA-N (mg/l)		TOTAL PHOSPHATE (as P) (mg/l)	
	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L	Avg.	H/L
1	3.76/3	4.03/3.40	0.08/3	0.10/0.05	0.369/3	0.42/0.27	0.70/3	0.12/0.09	0.01/3	0.01/ 0.01	0.03/3	0.04/0.03
1-A	3.48/4	3.50/3.42	0.08/4	0.10/0.05	0.32/4	0.38/0.24	0.10/4	0.14/0.09	0.02/4	0.04/ 0.01	0.03/4	0.05/0.02
1-F	4.07/4	5.50/0.75	0.19/4	0.25/0.00	0.37/4	0.55/0.12	0.09/4	0.22/0.04	0.07/4	0.10/ 0.01	0.03/4	0.06/0.01
1-G	3.70/4	3.95/3.50	0.15/4	0.18/0.12	0.29/4	0.41/0.20	0.07/9	0.08/0.05	0.02/4	0.03/ 0.01	0.03/4	0.06/0.02
2	3.64/4	3.83/3.50	0.14/4	0.20/0.10	0.39/4	0.70/0.20	0.10/4	0.11/0.18	0.08/4	0.20/ 0.01	0.04/4	0.06/0.02
2-A	2.37/3	2.45/2.30	0.04/3	0.05/0.03	0.34/3	0.64/0.18	0.13/3	0.15/0.12	0.01/3	0.01/ 0.01	0.02/3	0.02/0.02
2-B	1.48/3	1.62/1.35	0.07/3	0.11/0.05	0.23/3	0.37/0.14	0.09/3	0.12/0.07	0.01/3	0.02/ 0.01	0.02/3	0.02/0.01
3-Right Bank	4.17/4	6.10/3.22	0.25/4	0.42/0.18	0.40/4	0.44/0.36	0.09/4	0.10/0.07	0.07/4	0.10/ 0.08	0.04/4	0.04/0.03
3-Left Bank	3.90/1		0.21/1		0.31/1		0.09/1		0.03/1		0.03/1	
3-A	4.95/3	6.30/4.25	0.40/3	0.50/0.29	0.37/3	0.52/0.28	0.09/3	0.10/0.08	0.04/3	0.09/ 0.01	0.07/3	0.10/0.05
3-B	5.58/3	8.25/4.00	2.55/3	7.00/0.30	0.52/3	0.70/0.33	0.03/3	0.06/0.01	0.12/3	0.34/ 0.01	0.06/3	0.10/0.03
3-C	4.30/4	6.60/4.15	0.25/4	0.45/0.18	0.41/4	0.68/0.30	0.08/4	0.10/0.07	0.08/4	0.22/ 0.01	0.04/4	0.05/0.03
3-E	4.32/4	7.30/3.20	0.36/4	1.15/0.09	0.45/4	0.64/0.33	0.07/4	0.09/0.06	0.09/4	0.20/ 0.04	0.03/4	0.03/0.02
3-F	4.85/3	6.05/3.40	0.35/3	0.48/0.16	0.51/3	0.63/0.30	0.08/3	0.08/0.08	0.13/3	0.24/ 0.01	0.06/3	0.09/0.05
3-G	4.16/3	4.45/3.80	0.24/3	0.54/0.17	0.42/3	0.56/0.34	0.14/3	0.24/0.09	0.08/3	0.10/ 0.07	0.05/3	0.05/0.05
3-H	2.40/2	4.35/0.45	0.19/2	0.37/0.00	0.28/2	0.34/0.22	0.04/2	0.07/0.01	0.02/2	0.02/ 0.01	0.03/2	0.05/0.01
4	4.08/3	4.40/3.94	0.22/4	0.30/0.18	0.37/4	0.54/0.22	0.10/4	0.11/0.08	0.04/4	0.09/ 0.01	0.05/4	0.06/0.08
4-B	4.07/3	4.72/3.40	0.31/3	0.42/0.20	0.64/3	0.83/0.52	0.11/3	0.14/0.07	0.19/3	0.23/ 0.14	0.08/3	0.09/0.06
4-A	4.00/1		0.10/1		0.26/1		0.07/1		0.01/1		0.02/1	
5	5.00/3	5.96/4.30	0.21/3	0.25/0.19	0.51/3	0.68/0.31	0.09/3	0.10/0.07	0.11/3	0.16/ 0.06	0.06/3	0.07/0.05
6	4.80/4	5.55/4.18	0.23/4	0.24/0.18	0.57/4	0.80/0.42	0.10/4	0.11/0.08	0.09/4	0.19. 0.02	0.07/4	0.10/0.05
Water Plant (Lakes)	0.90/1		0.20/1		0.44/1		0.02/1		0.17/1		0.02/1	

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = Highest value
L = Lowest value

TABLE D-2 (Contd.)
AUGUST-SEPTEMBER, 1967 SURVEY DATA SUMMARY

STATION NUMBER	TOTAL COLIFORM (No./100 ml.) Avg.	TOTAL COLIFORM (No./100 ml.) H/L	FECAL COLIFORM (No./100 ml) Avg.	FECAL COLIFORM (No./100 ml) H/L	FECAL STREPTOCOCCI (No./100 ml) Avg.	FECAL STREPTOCOCCI (No./100 ml) H/L
1	10,000/2	16,000/4,000	140/2	140/135	220/2	350/95
1-A	6,700/4	12,200/4,100	100/4	115/80	100/3	115/80
1-F	6,100/2	7,200/5,000	85/2	90/80	50/2	60/40
1-G	6,600/2	10,000/3,200	145/2	160/130	290/2	470/120
2	6,300/4	7,700/4,800	210/4	290/150	80/3	120/60
2-A	19,000/2	26,000/12,000	780/2	1000/560	1,150/2	1,300/1,000
2-B	13,000/2	20,000/6,000	255/2	400/110	310/2	410/210
3-Right Bank	6,700/3	7,200/6,000	60/3	80/40	50/3	65/50
3-Left Bank	14,200/3	16,800/11,100	70/3	90/50	60/3	80/40
3-A	9,500/4	11,600/7,100	150/4	290/80	60/3	90/50
3-B	13,400/2	18,200/8,500	470/2	480/460	225/1	
3-C	6,400/4	8,600/3,300	95/4	140/60	100/3	130/80
3-E	7,500/4	10,500/3,300	90/4	150/50	90/3	115/80
3-F	17,200/2	22,000/12.300	305/2	320/290	265/1	
3-G	16,000/1	16,000/16,000	140/2	170/110	50/1	
3-H	14,200/1	14,200/14.200	80/1		330/1	
4	8,300/4	12,400/ 5,900	140/4	210/60	95/3	100/90
4-A	12,500/2	13,800/11,100	240/2	270/210	290/2	450/130
4-B	11,800/2	12,200/11,400	60/2	100/20	130/1	
5	10,400/2	16/700/4,000	180/2	240/120	100/1	
6	6,100/4	7,400/3,900	70/4	90/5	90/3	125/65
Water Plant (Lakes)	40/2		0/2		2/2	

Key: Avg = Average, with value as numerator and number of analyses as denominator.
H = highest value
L = lowest value

Table D-3 Distribution of invertebrates in Okatibbee Creek and tributaries, September 1967

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
TURBELLARIA												
Dugesia tigrina (Girard)				X	X			X			X	
Macrostomum sp.				X			X					
ANNELIDA												
Limnodrilus sp				X	X	X	X	X	X		X	X
Branchiura sowerbyi Bedd.					X				X	X		
Tubifex tubifex (OFM)												X
Helobdella sp.					X				X			
Theromyzon sp.						X	X					
CRUSTACEA												
Cyclops sp.	X	X	X		X			X		X	X	
Eurycercus sp.						X						
Asellus sp. (prob. militaris)		X		X	X	X	X	X			X	
Lirceus sp.			X		X	X			X	X		
Hyalella azteca (Saussure)				X								
Plalemonetes paludosus (Gibbes)					X					X		
Palaemonetes sp.				X								

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Procambarus sp.			X		X		X		X	X	X	
Cambarellus sp.				X								
Hydrachna sp.	X	X		X	X			X	X	X		
Limnochares sp.	X					X		X				
COLLEMBOLA												
Isotomurus palustris (Muller)												
HEMIPTERA												
Trichocorixa sp.	X			X			X					
Trepobates inermis Esaki	X										X	
Trepobates sp.					X					X	X	
Metrobates sp.		X										
Microvelia sp.			X									
Ranatra sp.					X					X	X	
ODONATA												
Argia moesta (Hagen)		X	X	X	X	X		X	X	X	X	
Argia putrida (Hagen)		X		X		X					X	
Argia sedula (Hagen)							X	X				

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Enallagma sp.				X								
Agrion maculatum Beauvois			X		X			X	X		X	
Gomphus sp.		X	X	X	X				X		X	
Progomphus obscurus Rambur								X	X			
Progomphus sp.			X	X								
Dromogomphus sp.								X	X	X	X	
Boyeria vinosa Say			X	X	X		X	X	X	X	X	
Macromia illinoiensis Walsh		X	X	X	X			X	X	X		
Neurocordula virginiesis Davis									X			
Perithemis tenera Say					X				X			
Tetragoneuria sp.				X								
EPHEMEROPTERA												
Hexagenia munda marilandica Traver			X	X								
Brachycercus sp.			X									
Caenis diminuta Walker			X	X		X						
Caenis hilaris (Say)	X				X	X	X			X	X	
Baetisca becki Schneider & Berner	X											

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Baetisca callosa Traver				X								
Choroterpes hubbelli Berner		X										
Tricorythodes albilineatus Berner	X				X				X	X	X	
Isonychia pictipes Traver	X											
Isonychia sp.									X	X		
Heptagenia sp.										X		
Stenonema exiguum Traver	X			X			X	X	X	X	X	
Stenonema integrum (McDunnough)	X											
Stenonema proximum Traver	X	X			X	X	X		X	X	X	
Stenonema smithae Traver		X	X	X	X	X	X	X	X		X	
Stenonema sp.		X			X	X			X			
Baetis intercalaris McDunnough	X			X	X	X		X	X	X		
Baetis spiethi Berner	X											
Baetis sp.		X	X						X			
Clocon rubropictum McDunnough				X							X	
Cloeon sp.				X						X		

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
PLECOPTERA												
Neoperla clymene (Newman)									X			
Phasganophora capitata (Pictet)									X			
Perlesta placida (Hagan)									X	X		
MEGALOPTERA												
Corydalus cornutus Latreille	X								X	X		
Sialis sp.		X	X	X	X	X						
TRICHOPTERA												
Chimarra sp.									X			
Phylocentrophus sp.				X		X			X			
Polycentrophus sp.				X	X	X			X			
Psychomyiid Genus A Ross							X			X		
Hydropsyche sp.							X	X	X			
Cheumatopsyche sp.	X			X	X		X		X	X	X	
Macronemum sp.					X				X			
Oxethira sp.	X								X	X		
Agraylea sp.	X											

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Oecetis inconspicua (Walker)			X	X		X						
Oecetis sp.				X	X		X	X	X		X	
Triaenodes sp.										X		
Brachycentrus sp.					X				X			
Pychopsyche sp.			X									
DIPTERA												
Dicranomyia sp.	X							X				
Eriocera fultonensis (Alexander)									X	X		
Tipula sp.										X		
Limnophila sp.										X		
Palpomyia sp.						X	X					
Probezzia sp.		X	X	X				X				
Chrysops sp.					X							
Atherix variegata Walker	X									X		
Simulium sp.	X		X	X	X				X			
Ablabesmyia hauberi Beck & Beck	X	X	X	X		X					X	X
Ablabesmyia janta (Roback)											X	X

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Ablabesmyia ornata Beck & Beck		X				X						
Ablabesmyia sp.		X	X		X	X		X	X	X		
Nilotanypus sp.											X	
Conchapelopia flavifrons (Johannson)	X	X	X	X	X	X	X	X		X		
Larsia sp.			X	X								
Guttipelopia sp.				X								
Coelotanypus concinnus (Coquillett)				X		X		X	X	X		
Clinotanypus sp.			X	X								
Procladius sp.		X										X
Monopelopia sp.											X	
Pentaneura inculta Beck & Beck											X	
Nanocladius alternanotherae Dendy & Sublette		X			X						X	
Cricotopus bicinctus (Meigen)	X	X			X				X	X		
Psectocladius sp.	X	X		X								
Corynoneura celeripes Winnertz			X						X			
Corynoneura sp.		X			X							
Thienemanniella xena Roback									X			

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Chironomus (chironomus) attenuatus Walker			X			X	X	X		X		
C. (Chironomus) stigmaterus Say			X									X
C. (Cryptochironomus) fulvus Johannsen		X	X	X				X		X	X	
C. (Cryptochironomus) sp.	X		X		X	X	X	X			X	
C. (Dicrotendipes) modestus Say						X	X					
C. (Dicrotendipes) neomodestus Malloch		X	X	X	X	X	X			X	X	
C. (Endochironomus) nigricans Johannsen	X	X	X		X	X	X	X	X		X	
C. (Tribelos) sp.		X	X			X						
C. (Xenochironomus) sp.									X			
Glyptotendipes meridionalis Dendy & Sublette							X					
Glyptotendipes sp.							X					
Polypedilum scalaenum (Schrank)								X		X		
Polypedilum fallax (Johannsen)	X	X	X	X	X	X		X	X		X	
Polypedilum illinoense (Malloch)	X		X	X					X	X	X	
Polypedilum halterale (Coquillett)		X	X	X	X	X						
Stenochironomus hilaris (Walker)	X			X						X		
Tanytarsus sp. B Beck	X	X	X	X	X	X		X				

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
Tanytarsus sp.	X		X		X	X	X	X	X	X	X	
Rheotanytarsus exiguus Johannsen	X	X	X	X	X	X	X					
COLEOPTERA												
Hydroporus sp.				X			X					
Haliplus punctatus Aube		X	X							X		
Dineutus discolor Aube	X								X	X		
Dineutus sp.				X			X	X			X	
Gyrinus woodruffi Fall			X	X			X					
Gyrinus sp.	X						X	X			X	
Berosus sp.										X		
Helichus fastigiatus (Say)	X		X	X	X	X				X		
Stenelmis convexula Sanderson	X	X	X		X	X	X			X	X	
Stenelmis sp.						X	X	X				
Dubiraphia sp.	X		X		X	X	X	X	X	X	X	
Macronychus glabratus Say		X							X	X		
Ancyronyx sp.				X					X	X		

TABLE D-3 (Contd.)

Organisms	Stations											
	1	1A	2A	2B	4	4A	4B	6	7	8	9	10
MOLLUSCA												
Crenodonta sp.									X	X		
Anodonta hallenbecki Lea									X			
Sphaerium sp.	X	X	X	X	X	X						
Pisidium sp.	X	X	X	X								
Corbicula sp.									X	X		
Viviparus sp.												
Campeloma sp.								X	X			
Goniobasis sp.									X			
Pseudosuccinea columella Say										X		
Ferrissia sp.									X	X		
Physa sp.					X		X			X	X	X
TOTAL NUMBER OF SPECIES	40	37	45	56	49	40	35	36	58	54	39	7

D-18

APPENDIX E

BIOLOGICAL SURVEY TECHNIQUES

BIOLOGICAL SURVEY TECHNIQUES

METHODS AND MATERIALS

According to the method of Hester and Dendy (13), artificial substrata were placed at each biological sampling station. This method was selected because it offered the advantages of standardization in size, shape, composition of material, and length of exposure. It consists of a large sheet of 1/8 inch masonite cut into two sizes of square plates, each with a hole in its center. The larger plates (3 inches square) and the smaller separator plates (1 inch square) are alternately placed on a 1/4 inch bolt, 3.5 inches long. When tightened between nuts on each end of the bolt, the plates are held in place with distances of approximately 1/8 inch between the larger plates, providing spaces for biota. Eight 3 x 3 inch plates are used for each sampler so that the surface area is approximately 144 square inches, or one square foot.

Two multiple-plate devices were placed at each sampling station. The devices were suspended at mid-depth by a wire tied, several feet above the water level, to bridge pilings. After being submerged one month, they were gently taken from the water and disassembled in a flat-bottomed, white enamel pan. Organisms were separated into taxonomic groups and preserved in appropriately labeled vials containing 70 percent ethyl alcohol. This method afforded an opportunity to apply quantitative and qualitative values to the data.

The artificial substrata primarily collects syrton.[1/] In order to obtain additional qualitative information, dipnet samples of bottom deposits were

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1/ A heterogeneous, macroscopic group of organisms that drift with the stream currents.

collected. San, clay and vegetative detritus were washed through a 38 mesh Ward dipnet; organisms were separated from the debris and preserved as described above. Logs, boards, rocks and other submerged objects were brought to the surface. Macroinvertebrates were hand-picked with forceps and preserved.

In the laboratory, organisms collected from the artificial substrata devices were counted and specifically identified. Collections from the dipnet sampling were identified also, but no quantitative areal measure was made of this material.

Table D-4

Average number of invertebrates collected from multiple-plate samplers in Okatibbee Creek and tributaries, September 1967

ORGANISM	NUMBER per square foot
Station 1:	
Ephemeroptera	
Isonychia sp.	5
Stenonema exiguum Traver	6
Stenonema integrum (McDunnough)	10
Baetis intercalaris McDunnough	2
Diptera	
Atherix variegata Walker	2
Simulium sp.	11
Ablabesmyia hauberi Beck & Beck	4
Conchapelopia sp.	3
Cricotopus bicinctus (Meigen)	3
Psectocladius sp.	5
Chironomus (Cryptochironomus) sp.	1
C. Endochironomus nigricans Johannsen	2
Polypedilum fallax (Johannsen)	15
Polypedilum illinoense (Malloch)	1
Tanytarsus sp. *B* Beck	4
Rheotanytarsus exiguus Johannsen	2
Coleoptera	
Gyrinus sp.	1
Total	77

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Station 1A:	
Crustacea	
Hydrachna sp.	1
Odonata	
Argia moesta (Hagen)	1
Argia putrida (Hagen)	2
Ephemeroptera	
Stenonema proximum Traver	6
Stenonema smithae Traver	5
Stenonema sp.	1
Baetis sp.	1
Diptera	
Ablabesmyia hauberi Beck & Beck	1
Ablabesmyia ornata Beck & Beck	3
Ablabesmyia sp.	4
Conchapelopia sp.	1
Procladius sp.	3
Psectocladius sp.	3
Corynoneura sp.	2
Chironomus (Dicrotendipes) sp.	2
C. Endochironomus nigricans Johannsen	4
C. Tribelos sp.	2
Polypedilum fallax (Johannsen)	2

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Polypedilum halterale (Coquillett)	2
Tanytarsus sp B Beck	10
Rheotanytarsus exiguus Johannsen	4
Coleoptera	
Stenelmis convexula Sanderson	1
Total	61
Station 2A:	
Odonata	
Argia moesta (Hagen)	1
Ephemeroptera	
Stenonema smithae Traver	1
Diptera	
Ablabesmyia hauberi Beck & Beck	4
Ablabesmyia sp.	2
Conchapelopia sp.	4
Larsia sp.	1
Corynoneura celeripes Winnertz	2
Chironomus (Cryptochironomus) fulvus Johannsen	4
C. Cryptochironomus sp.	4
C. Dicrotendipes sp.	9
C. Endochironomus nigricans Johannsen	9
C. Tribelos sp.	6
Polypedilum fallax (Johannsen)	10

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Polypedilum illinoense (Malloch)	5
Tanytarsus sp B Beck	6
Rheotanytarsus exiguus Johannsen	4
Coleoptera	
Helichus fastigiatus (Say)	1
Dubiraphia sp.	2
Mollusca	
Sphaerium sp.	3
Total	78
Station 2B:	
Turbellaria	
Dugesia trigina (Girard)	7
Annelida	
Limnodrilus sp.	2
Crustacea	
Hydrachna sp.	1
Odonata	
Argia putrida (Hagen)	1
Boyeria vinosa Say	1
Ephemeroptera	
Caenis diminuta Walker	2
Stenonema exiguum Traver	4
Stenonema smithae Traver	9

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Baetis intercalaris McDunnough	5
Megaloptera	
Sialis sp.	2
Tricoptera	
Polycentropus sp.	1
Cheumatopsyche sp.	7
Oecetis sp.	1
Diptera	
Probezzia sp.	2
Simulium sp.	2
Conchapelopia sp.	17
Guttipelopia sp.	1
Polypedilum fallax (Johannsen)	4
Tanytarsus sp B Beck	1
Rheotanytarsus exiguus Johannsen	26
Coleoptera	
Hydroporus sp.	2
Dineutus sp.	2
Helichus fastigiatus (Say)	6
Ancyronyx sp.	2
Total	108

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Station 4:	
Turbellaria	
Dugesia tigrina (Girard)	3
Annelida	
Limnodrilus sp.	2
Odonata	
Argia moesta (Hagen)	1
Ephemeroptera	
Stenonema proximum Traver	8
Stenonema smithae Traver	5
Stenonema sp.	2
Megaloptera	
Sialis sp.	1
Trichoptera	
Polycentropus sp.	2
Cheumatopsyche sp.	5
Diptera	
Simulium sp.	6
Ablabesmyia sp.	2
Conchapelopia sp.	3
Cricotopus bicinctus (Meigen)	2

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Corynoneura sp.	1
Chironomus (Endochironomus) nigricans Johannsen	4
Polypedilum fallax (Johannsen)	6
Tanytarsus sp. B Beck	1
Rheotanytarsus exiguus Johannsen	2
Total	56
Station 4A:	
Annelida	
Limnodrilus sp.	3
Crustacea	
Asellus sp.	1
Limnochares sp.	2
Odonata	
Argia moesta (Hagen)	1
Ephemeroptera	
Caenis hilaris (Say)	1
Stenonema smithae Traver	2
Diptera	
Ablabesmyia hauberi Beck & Beck	2
Ablabesmyia sp.	1
Conchapelopia sp.	2
Chironomus (Endochironomus) nigricans Johannsen	5
C. Tribelos sp.	3

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Polypedilum fallax (Johannsen)	7
Polypedilum halterale (Coquillett)	1
Tanytarsus sp B Beck	4
Rheotanytarsus exiguus Johannsen	8
Coleoptera	
Stenelmis convexula Sanderson	2
Stenelmis sp.	1
Dubiraphia sp.	1
Mollusca	
Sphaerium sp.	1
Total	48
Station 4B:	
Turbellaria	
Macrostomum sp.	3
Annelida	
Limnodrilus sp.	2
Theromyzon sp.	1
Crustacea	
Asellus sp.	8
Odonata	
Argia sedula (Hagen)	1
Boyeria vinosa Say	1

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Ephemeroptera	
Caenis hilaris (Say)	1
Stenonema exiguum Traver	1
Stenonema proximum Traver	4
Stenonema smithae Traver	3
Trichoptera	
Hydropsyche sp.	3
Diptera	
Conchapelopia sp.	2
Glyptotendipes meridionalis Dendy & Sublette	6
Glyptotendipes sp.	2
Rheotanytarsus exiguus Johannsen	6
Coleoptera	
Stenelmis convexula Sanderson	1
Dubiraphia sp.	2
Mollusca	
Physa sp.	6
Total	53
Station 6:	
Turbellaria	
Dugesia tigrina (Girard)	
Annelida	
Limnodrilus sp.	7

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Crustacea	
Asellus sp.	2
Hydrachna sp.	4
Limnochares sp.	3
Odonata	
Argia moesta (Hagen)	1
Argia sedula (Hagen)	3
Agrion maculatum Beauvois	2
Ephemeroptera	
Stenonema smithae Traver	2
Baetis intercalaris McDunnough	1
Diptera	
Ablabesmyia sp.	2
Conchapelopia sp.	4
Chironomus (Cryptochironomus) sp.	1
C. Endochironomus nigricans Johannsen	4
Polypedilum scalaenum (Schrank)	1
Polypedilum fallax (Johannsen)	3
Tanytarsus sp. B Beck	5
Coleoptera	
Dubiraphia sp.	2
Mollusca	
Campeloma sp.	1
Total	49

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Station 7:	
Annelida	
Limnodrilus sp.	1
Crustacea	
Lirceus sp.	2
Ephemeroptera	
Isonychia sp.	4
Stenonema exiguum Traver	2
Stenonema proximum Traver	2
Stenonema smithae Traver	16
Stenonema sp.	1
Baetis sp.	1
Plecoptera	
Neoperla clymene (Newman)	2
Megaloptera	
Corydalus cornutus Latreille	2
Diptera	
Ablabesmyia sp.	1
Cricotopus bicinctus (Meigen)	3
Corynoneura celeripes Winnertz	2
Thienemanniella xena Roback	2
Polypedilum illinoense (Malloch)	5
Tanytarsus sp.	1

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Coleoptera	
Dubiraphia sp.	2
Ancyronyx sp.	1
Mollusca	
Ferrissia sp.	2
Total	52
Station 8: (SAMPLERS REMOVED BY THE MISSISSIPPI HWY DEPT)	
Station 9:	
Annelida	
Limnodrilus sp.	3
Crustacea	
Asellus sp.	1
Odonata	
Argia moesta (Hagen)	1
Argia putrida (Hagen)	2
Ephemeroptera	
Tricorythodes albilineatus Berner	1
Stenonema exiguum Traver	2
Diptera	
Ablabesmyia hauberi Beck & Beck	6
Nilotanypus sp.	1
Pentaneura inculta Beck & Beck	8

Table D-4 (Contd.)

ORGANISM	NUMBER per square foot
Nanocladius alternanotherae Dendy & Sublette	3
Chironomus (Dicrotendipes) sp.	3
Polypedilum fallax (Johannsen)	2
Tanytarsus sp.	2
Coleoptera	
Dubiraphia sp.	1
Mollusca	
Physa sp.	1
Total	37
Station 10:	
Annelida	
Limnodrilus sp.	12
Tubifex tubifex (O.F.M.)	8
Diptera	
Ablabesmyia janta (Roback)	6
Procladius sp.	1
Chironomus stigmaterus Say	46
Mollusca	
Physa sp.	4
Total	77

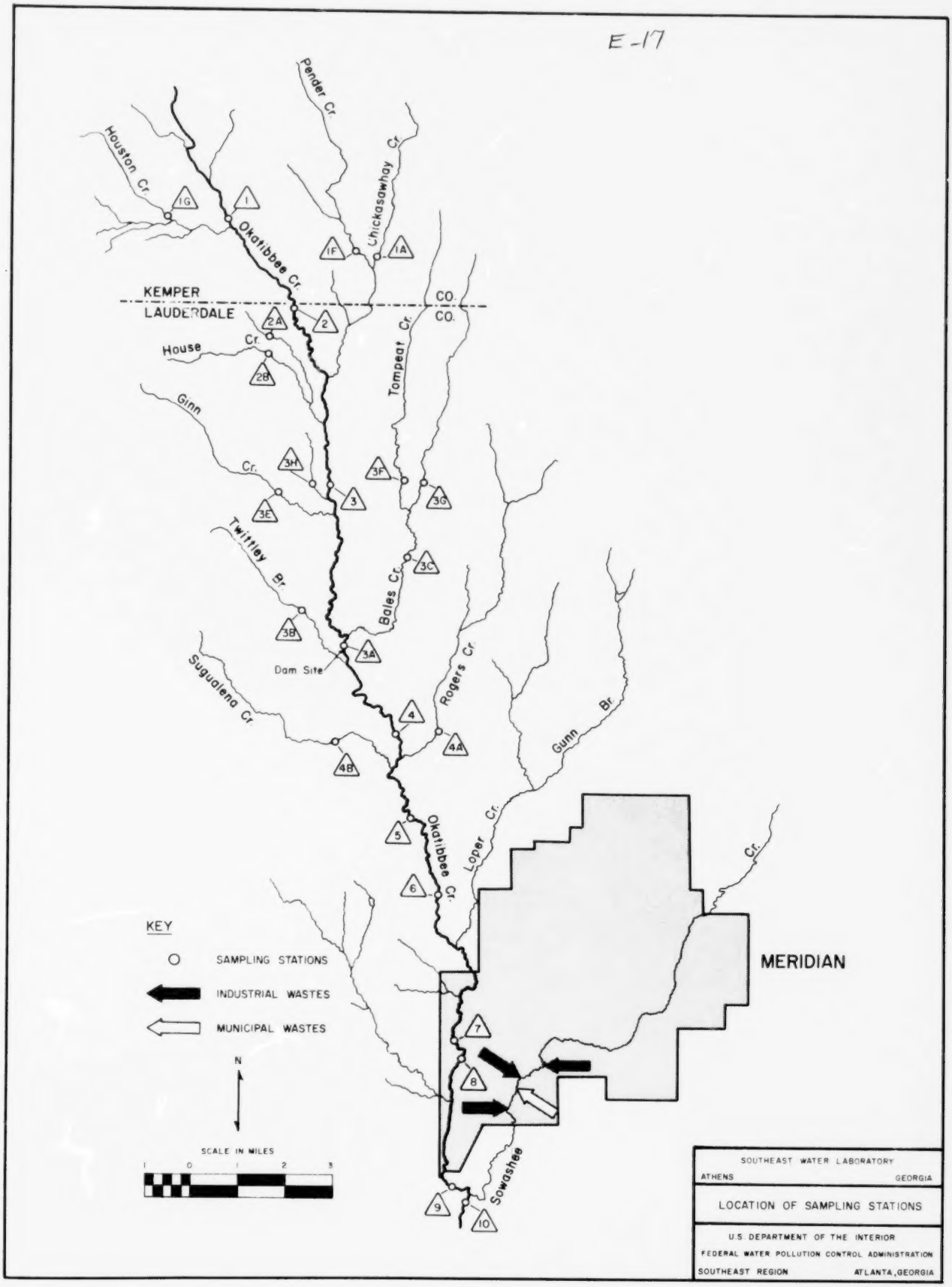
Pender Cr.
Houston Cr.
Chickasawhay Cr.
Okatibbee Cr.
1G
1
1F
1A
KEMPER
LAUDERDALE
CO.
CO.
2A
2
House
Cr.
2B
Tompeat Cr.
Ginn
Cr.
3H
3F
3
3G
3E
Twittley Br.
Bales Cr.
3C
3B
3A
Dam Site
Rogers Cr.
Suguaiena Cr.
4
4A
Gunn Br.
4B
5
Okatibbee Cr.
Loper Cr.
Cr.
6
KEY
SAMPLING STATIONS
INDUSTRIAL WASTES
MUNICIPAL WASTES
MERIDIAN
7
N
8
SCALE IN MILES
1 0 1 2 3
Sowashee
9
10
SOUTHEAST WATER LABORATORY
ATHENS GEORGIA
LOCATION OF SAMPLING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTHEAST REGION ATLANTA, GEORGIA

FIGURE 2